STUDY ON HOSPITAL DESIGN AND IT'S TRANSITION DURING PANDEMIC SITUATION

A Dissertation Submitted for the Degree of Master

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ABSTRACT

With the advancement of global medical technology and the rapid development of urbanization, hospital construction has entered a new era. The evolution of the medical model and the development of medical technology have placed higher requirements on the overall planning and design of hospital buildings. The changes in the spectrum of human diseases and the aging of the population have also constantly put forward new requirements for architectural spaces. Many factors make it difficult for traditional hospital architectural design to meet the requirements of flexible development.

With the beginning of December 2019, under the background of the global outbreak of covid-19, the paper launched a study on emergency hospital design and prefabricated hospital buildings.

The thesis first investigated the emergency design of some general hospitals, and summarized the emergency response mode such as war epidemic situation. Secondly, the thesis investigates and studies how Wuhan, China has completed the construction of emergency prefabricated hospitals in a short period of time with high efficiency and high quality, and it has also effectively treated patients under the premise of ensuring the health and safety of medical staff. Finally, according to the covid-19 situation of Trofarello in Italy, the design principles of the hospital's transition during a pandemic situation were put forward in a targeted manner, and an emergency hospital that could successfully respond to the epidemic will be designed.

key words: emergency hospital; prefabricated hospital; epidemic ; pandemic ; covid-19.

CONTENT

Introduction

A sudden outbreak of covid-19 affected everyone more or less in the world. Not to be discussed at the national level, covid-19 has a great impact on the lives, spirit and economy of people:

Due to the expansion of the epidemic, the amount of travel has decreased. At home, to fight the epidemic, the security of life must be second to normal. For example, in terms of food, due to the closure of the country and the city, many avtivities are closed, and it is necessary to purchase and cook for themselves. Although the country stabilizes prices, they also rise to varying degrees in terms of prices;

From busy work to sudden idle life, there will be a huge emptiness on the spiritual level. There are also a few people who have left due to the epidemic. The prolonged epidemic time and various house loans and car loans have increased the anxiety of people;

The spread of the epidemic will directly affect global transportation, tourism and other industries. Among them, the real economy of various countries will be greatly affected. After resuming work, it will become an inevitable trend that some small and medium-sized enterprises cannot properly respond to the failure caused by the epidemic.

Through this epidemic, we realized that the soundness of the medical system is very necessary for national construction and development. An efficient medica system will enable a country to quickly deal with the needs of many people in terms of disasters, save people's lives, reduce public opinion, and stimulate people's patriotic feelings. Therefore, after this epidemic, the world's medical system will be highly valued by various countries and focused on development. Under this general environment, the construction of new hospitals is also essential. This paper will analyze the prefabricated hospitals and Wuhan Leishenshan Hospital in order to design modular prefabricated hospitals that can convert to respond the pandemic situation.

Chapter 1 The Emergency Hospital

1.1 The significance of emergency hospital building in cities

The city's disease resistance practice has proved that health issues must be incorporated into urban planning strategies. Relevant infrastructure construction should be considered during urban planning to improve the city's ability to respond to major public health emergencies.

First, the spatial layout of urban planning can be modeled on the setting of disaster prevention and refuge parks, and the site selection of large emergency epidemic treatment hospitals should be done during planning, replacing the access conditions for transportation and infrastructure, and pre-building corresponding supporting facilities in advance. Prepare engineering design and prepare for approval, which can be quickly activated in an emergency.

The second is that in the future large cities and megacities should build core medical facilities to deal with public health emergencies as early as possible. When planning and designing conventional medical facilities, it is necessary to consider whether they can be quickly converted into epidemic treatment hospitals.

The third is to consider the interface and space of emergency epidemic prevention and treatment facilities in the planning and design of gymnasiums, exhibition halls, convention centers, green space plazas, etc., thus becoming a strategic reserve of urban medical resources.

Medical buildings and public building facilities need to take into account epidemic prevention design. General hospitals with first-class diagnosis and treatment technology have little effect because the hardware facilities cannot meet the requirements of professional sensory control.[1]

First, in the design or reconstruction of large-scale general hospitals, consider adding an additional infectious disease backup diagnosis and treatment area with a moderate scale and high sense of hospital control outside the conventional wards, causing common wards during non-epidemic periods, and major infectious diseases. When an epidemic occurs, it can be quickly transformed into a functionally independent treatment area for infectious disease patients.

Another option is the construction of specialized infectious disease treatment hospitals, which should take into account the needs of conventional comprehensive medical treatment and brake as a large specialty general hospital of various local infectious diseases during the non-epidemic period, and can quickly undertake comprehensive anti-epidemic treatment services when the outbreak occurs.

It can be also possible to formulate the “*standard of anti-epidemic for large urban public buildings*” to quickly transform them into the necessary interface and space for the sheltered hospitals that meet the requirements of anti-epidemic.

"Quick response, rapid construction" is an important requirement for emergency and

epidemic prevention construction, and prefabricated buildings can greatly increase the construction speed of emergency and epidemic prevention projects.

One solution can be to publish policies to clarify the scope and incentive measures and standards of assembly-type priority promotion projects. The government-invested construction of security houses, resettlement houses, large-scale public buildings and other projects can be the first to promote the pilot. Meet the evaluation conditions, at the same time give credit to the participating units in terms of credit, finance and taxation, and accelerate the development of prefabricated buildings.

Another option can be to strengthen the strategic resource reserves of assembled industries. In terms of labor resource reserves, all localities should train industrial chemical workers with excellent professional skills. Regarding prefabricated construction enterprises, it is recommended that local governments support specific emergency and epidemic prevention construction enterprises, such as general contractor construction enterprises and prefabricated component factories. Such enterprises provide support in terms of enterprise qualification and personnel training. When the epidemic strikes again, such enterprises can respond quickly and quickly invest in the construction of emergency epidemic prevention facilities.

1.2 The particularity of emergency infectious disease hospital design

The design of infectious disease hospital is different from that of general hospital. The design principle of infectious disease hospital is to cut off the transmission chain and control the source of infection in the aspects of pathogen, host and environment.

Infectious disease hospital should make clear the function division, make clear the clean area and dirty area division of each department. In the plane layout, the medical area should be divided into three areas: clean area, semi-clean area or semi-dirty area and dirty area.[2] It shoule pay special attention to the relative division between the patient activity area and the medical staff working area in the medical area , In order to reduce the chance of contact and infection between clean and polluted people and logistics.

The design of infectious disease hospital should not only prevent the dirty outside the hospital from interfering with the medical treatment area, but also prevent the management and control of the dirty sources inside the hospital, so as not to cause secondary dirty.The disposable articles, gauze, food residue, excreta, blood samples, body fluid specimens and pathological tissue specimens used by the patients should be collected according to the different infectious diseases, and the collection should be conducted by the designated person, so as to take reliable sterile disinfection measures.All kinds of people and logistics to have a clear scientific planning, take strict measures.

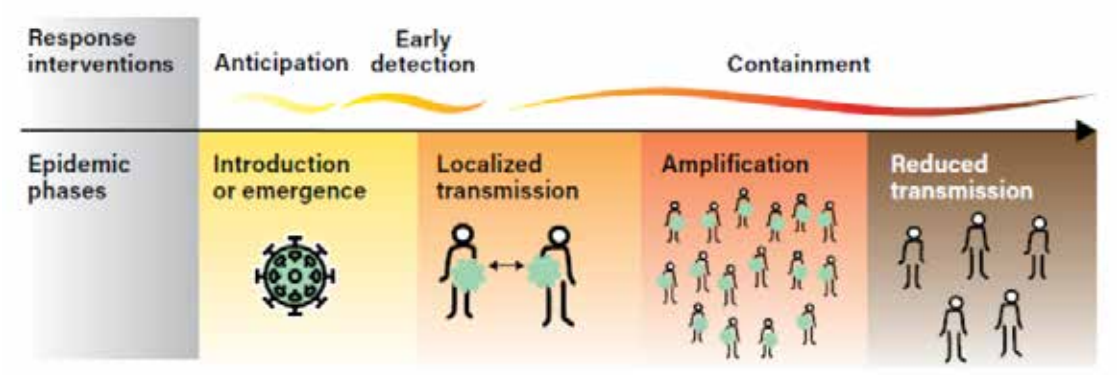
There are several difficulties in the design of infectious disease hospital. A problem, often not considered, is that the design should take into account the medical environment of patients seeking medical treatment, as well as the environmental space of medical staff who have been working here for a long time, so as to create a humanized and green ecological indoor and outdoor environment as much as possible.[2]

1.3 WHO instructions for the construction of Severe Acute Respiratory Infections Treatment Centre

1.3.1 Epidemic phases and stages of intervention

The dynamics of epidemics and pandemic diseases are usually divided into four stages. The first stage is to introduce the community. The second stage is a localized outbreak, in which sporadic infections can occur. In the third stage, when the pathogen can spread from person to person and cause a continuous outbreak in the community, the outbreak will magnify into an epidemic or pandemic and may spread to the entire epidemic. The fourth stage is the reduction of transmission, which is due to the acquired population immunity or effective interventions to control the disease, which leads to a reduction in the transmission of pathogens from person to person.[3]

As noted above, the dynamics of an epidemic determine the sequence of necessary responses and subsequent interventions.There are several key stages: the expectation that emerging and re-emerging diseases will prompt faster detection and response; early discovery of the emergence of animal and human populations;control the disease in its early stages of transmission; prevention and control work during the epidemic expansion period.



Epidemic phases and response interventions [3]

1.3.2 Ventilation and exhausted air

Introduce outdoor air into the building or room, and distribute the air in the building or room through different ducts for ventilation. Provide healthy breathing air to patients and healthcare workers by diluting and removing pollutants in buildings.

Building ventilation has three basic elements: ventilation rate, quantity and quality of outdoor air entering the space; airflow direction, the overall airflow direction in the building should be from clean area to dirty area; air distribution method, effective delivery of external air to the space Each part of the space should be effectively removed from the airborne pollutants generated in each part of the space.[3]

Three methods can be used to ventilate buildings: natural ventilation, mechanical ventilation and mixed ventilation.

The air in the room can be discharged directly to the outside, where the droplet core will be diluted in the outdoor air, or most (99.97%) of the droplet core will be filtered through a special HEPA filter, and then returned to the ordinary circulation. If a HEPA filter is not

used, the air should be discharged directly from the outside air inlet to people and animals. Air dilution should always be the preferred solution. However, if it is not possible, three different methods of exhaust gas treatment are proposed here.

1.3.3 Screening basic layout priciples for health-care facilities

The recommended layout is based on standard screening settings, supplemented by appropriate ventilation infections, prevention and control measures. There are the following assumptions behind this layout:Provide protocols for patient screening (including designated screening areas) and patient traffic in and around hospitals.Staffing is provided for newly designated hospital areas (such as new inspection areas and isolation rooms). The hospital uses screening criteria to treat severely ill patients and treatable epidemic patients. In some cases, health authorities may require health agencies to concentrate on providing health services to non-epidemic patients and refer epidemic patients elsewhere.

The purpose of this section is to introduce different methods of establishing waiting rooms and classification areas that are particularly suitable for COVID-19 in the following situations:

Newly constructed concrete buildings or semi-permanent structures; the standards presented here can also be used to repurpose existing buildings.

Large tents (>100 square meters) are commonly used in humanitarian agencies, agencies and UN agencies to build warehouses and large-capacity shelters in emergencies.

Standard size tents (approximately 45 square meters) commonly used by humanitarian actors, agencies, and UN agencies for emergency response.

According to "*Practical manual to set up and manage a SARI treatment centre for WHO*" [3], this thesis analyzes in detail the Leishenshan Hospital built in China specifically for covid-19, including its Location analysis, Construction record, function division, human flow,Unit plane and structural analysis.

1.4 Five epidemic response models for urban emergency hospitals in China

During the SARS outbreak in 2003, Beijing built the xiaotangshan hospital to treat patients in a centralized way.

During the covid-19 outbreak in 2020, Huoshenshan hospital and Leishenshan hospitals were urgently built in wuhan, Beijing announced the reconstruction of Xiaotangshan hospital, Shenzhen and Zhengzhou built Xiaotangshan model hospitals on the reserved sites of existing hospitals, Shanghai and Nanjing expanded public health clinical centers, and some cities temporarily renovated existing hospitals.

When the covid-19 broke out, different cities took different emergency measures. Some cities already had emergency standby plans, while others acted in a hurry. The speed of emergency response varied, resulting in different effects of emergency treatment.

First-tier developed cities, such as Beijing, Shanghai and guangzhou, have a high level of medical treatment, and have specialized hospitals and general hospitals for infectious diseases. They can directly deal with the large-scale outbreak of general infectious diseases. Second-tier cities like Wuhan, with modest medical facilities, are not able to deal directly with the outbreak of serious infectious diseases, but can manage with the help of other cities. Third-tier and fourth-tier cities have a general medical level and fewer beds for infectious diseases. Therefore, large-scale outbreaks of common infectious diseases may be difficult to deal with.

Therefore, every city, regardless of the current medical level, will encounter the problem of insufficient capacity of infectious disease hospitals in the face of a major outbreak of the epidemic. Therefore, emergency standby hospitals for infectious diseases are particularly important.However, what kind of emergency standby hospital for infectious diseases can be built to provide a large number of beds quickly and meet the requirements of timely treatment?

This work compared the different cities of the country's emergency hospital of infectious diseases, from the aspects of hospital construction and operation, and summarizes the five main epedemic mode, analyzes the different cities should take what kind of pandemic mode, how can fast startup emergency hospital, in the event of an outbreak if Xiaotangshan hospital construction to further shorten the time and how to solve the problem of emergency hospital daily operations difficult.

1.4.1 Temporary emergency mode of Xiaotangshan Hospital (Beijing)

When SARS emergency in 2003 the construction of the Beijing xiaotangshan hospital, after the SARS medical level rapid development, now Beijing has 10058 medical and health institutions, 553 armour hospitals, two large specialized subject hospitals of infectious diseases.[4] But 17 years later, as in the face of the new champions announced restart xiaotangshan hospital, Wuhan is rapidly built Huoshenshan hospitals and Leishenshan hospital, visible this emergency mode is very effective, but it also has some shortcomings, will not dismantle or Beijing xiaotangshan hospital.

In order to understand the model of xiaotangshan hospital, we need to review the 17

years' experience of Beijing xiaotangshan hospital.In the face of sudden SARS virus in 2003, Beijing ditan hospital, Beijing youan hospital and other infectious disease specialist hospital ability is limited, and general hospital and worry about treating SARS patients can cause cross infection, then the emergency decision reference field hospital model, in changping district of Beijing xiaotangshan nursing homes, building a 1000 - bed capacity Beijing xiaotangshan hospital, as a concentrated SARS patients in our hospital emergency hospital of infectious diseases.

The hospital was built in 7 days, working day and night from April 24 to April 30. Beijing xiaotangshan hospital was quickly built in 7 days, setting a record for the world's fastest hospital construction speed.

From May 1 to June 20, a total of 680 SARS patients were treated in Beijing Xiaotangshan hospital, accounting for 28% of the total number of infected people in Beijing. Among them, 672 patients were discharged from hospital and 8 died, with the lowest mortality rate in China, and none of the 1,383 medical workers were infected.[4]

Xiaotangshan hospital under construction [4]

Xiaotangshan hospital after construction [source network]

On June 21, the ward of xiaotangshan hospital was completely disinfected, and the isolation ward was closed. On June 22, the ward was officially handed over to the Beijing municipal government for management.Beijing xiaotangshan hospital completed the expected emergency treatment function, leaving a strong mark in the fight against SARS, since then, "xiaotangshan hospital" has become a special pronoun.

However, after SARS, the question of whether Xiaotangshan hospital should stay or go has been widely discussed by officials and experts. Some people believe that Xiaotangshan hospital is a temporary building, which cannot bear the functions of a permanent hospital for infectious diseases. Some people worry that SARS will come back, after the demolition may have to be hastily built, the proposal to retain, but retain for how long, who will maintain, how much to maintain the cost, these have become difficult problems. At that time, it was concluded that Xiaotangshan hospital should not be dismantled for the time being, and should be kept as a treatment base for preventing the rebound of SARS epidemic in Beijing for a period of time.

But after that, Xiaotangshan hospital seemed to be forgotten, with no management or maintenance, piles of garbage, overgrown weeds and desolate places, just like a "no man's land".

Refactoring: 3 years Beijing health bureau announced plans to use 3 years to reconstruct Beijing infectious disease medical institutions treat network, gradually set up in 560 class hospital outpatient clinic, more than 142 secondary hospital of infectious diseases

infectious diseases as the foundation, with 61 general hospital infectious disease isolation room under observation as the main body, based on two infectious disease specialist hospital of infectious diseases treatment of medical institutions network.After the completion of construction, the number of infectious beds in Beijing will increase from the current 1,370 to 1,670, and there will be 5,000 emergency beds, basically able to cope with large-scale outbreaks of common infectious diseases.[4]

Seven years later, on April 2, 2010, the Beijing municipal health bureau announced the demolition of the SARS ward of Beijing Xiaotangshan hospital, the main reason is that the Xiaotangshan hospital is a temporary building, which has exceeded the 3-year building service life, after expert demonstration, has lost its use value and cannot be used again.
Nine years later, on September 5, 2012, the Beijing municipal health bureau approved the change of the name of "Beijing Xiaotangshan rehabilitation hospital" to "Beijing Xiaotangshan rehabilitation hospital", and Xiaotangshan hospital was transformed into a level-iii, grade-a rehabilitation hospital focusing on rehabilitation.


abandoned Xiaotangshan hospital [4]


dismantled Xiaotangshan hospital [source network]

After 17 years of reconstruction, on January 28, 2020, the Beijing municipal commission of health said that "the renovation project of Beijing Xiaotangshan hospital has been started, depending on the changes in the epidemic situation as a supplement", and the reconstruction and repair work was completed in mid-late February.

From 2003 to 2020, Beijing Xiaotangshan hospital experienced the whole process of new construction, retention, demolition, transformation and reconstruction. From the experience of 17 years, xiaotangshan hospital is positioned as an emergency hospital for infectious diseases, which is a passive emergency measure rather than an active standby measure. Emergency operation was started in the outbreak of the epidemic, but it was neither used nor maintained after the epidemic, and gradually abandoned and dismantled. However, the workload of rebuilding the epidemic was still huge, which could not save much time compared with the newly built hospital.


demolition of Xiaotangshan hospital [source network]


reconstruction of Xiaotangshan hospital [5]

1.4.2 General hospital "combination of peacetime and wartime" emergency mode (Guangzhou)

Guangdong province, as another major site of SARS prevention and control, has accumulated rich experience in infectious disease treatment in 2003. Under the leadership of academician zhong nanshan, a leading figure in the fight against SARS and a famous respiratory expert, the theoretical level and management level of infectious disease treatment in guangdong province are among the top in China.

After SARS, health department of guangdong province has established the system of infectious diseases treated construction guidance ", put forward to use a year and a half time, basic construction and improvement of covering the entire province city and countryside, can response to major infectious disease outbreak, more complete and strong ability of medical treatment of infectious disease treated system in guangdong province, to adapt to the usual acute infectious diseases and sudden major medical and biological terrorism admission requirements.

the second people's hospital of Guangdong province [source network]

The medical treatment and treatment system for infectious diseases in Guangdong province consists of specialized hospitals for infectious diseases, backup hospitals for infectious diseases, infectious diseases departments (wards) of general hospitals at and above the county level, and other infectious diseases receiving and treatment institutions, as well as technical teams and equipment for medical treatment of infectious diseases, forming a network for the acceptance and treatment of infectious diseases at provincial, municipal and county levels.The infectious disease departments of specialized hospitals and general hospitals are the basic guarantee for the prevention and treatment of infectious diseases, as well as the regular army and the main force. Guangdong and Beijing have attached special importance to the construction of this field.

But it is different from Beijing, to articulate the infectious disease treated backup hospital of guangdong province, and the second people's hospital of Guangdong province identified as the province only hospital emergency backup at the provincial level, two hundred million new emergency medical building, constructing the emergency medical rescue command platform, equipped with a series of emergency rescue equipment.

The second people's hospital of Guangdong province adopts the "combination of peacetime and wartime" mode, which is operated as a general hospital at ordinary times, with beds open to ordinary patients. In the case of major emergencies, the hospital is transformed into a specialized hospital for infectious diseases, where patients with infectious diseases are treated centrally.

Temporary emergency mode than Xiaotangshan hospital, discussed combined with the model is a good way to balance the hospital daily operations and major epidemic emergency needs, maintain daily operation system can guarantee system, doctors, nurses and medical supplies are ready, need to quickly switch function only when major outbreaks, construction, without the need for a separate switch much faster than a new hospital, also avoid the Beijing Xiaotangshan hospital usually putting-in-service proactively, maintenance difficulties.

The combination of "existing hospital + Xiaotangshan hospital" has created another emergency mode combining peacetime and wartime.

the Shenzhen no. 3 people's hospital [source network]

Shenzhen, also a first-tier city, has a large gap in medical capacity compared with guangzhou. There is only one specialized hospital for infectious diseases in shenzhen - shenzhen no. 3 people's hospital (referred to as "shenzhen no. 3 hospital"). However, facing the severe test of 8 million people returning to the deep tide after the Spring Festival, the capacity of Shenzhen to treat infectious diseases is obviously insufficient.

Shenzhen not alone somewhere new Xiaotangshan hospital, but in Shenzhen on the expansion of the field, the research use 20 days for rapid construction of the second phase, also is take the xiaotangshan hospital model of prefabricated construction technology, but the operation pattern, shenzhen clear the research and the subsequent operation, the pattern of "discussed in combination with" during the outbreak of the new champions league play a contingency function, after the outbreak of major infectious diseases in clinical medical research.

Similar practices have been adopted in other cities. For example, the second people's hospital of Zhongshan city has expanded the "Xiaotangshan hospital" in two phases in the open space of the basketball court, and the first people's hospital of Zhengzhou city has

expanded the "Xiaotangshan hospital" at the site of the first people's hospital port district hospital. After the epidemic, the hospital will also operate in a peacetime and wartime mode.

The "combination of peacetime and wartime" mode of general hospitals takes into account both emergency and standby. The combination of "existing hospitals + Xiaotangshan hospital" has less active standby, but once the Xiaotangshan mode is built on the expansion site of the existing hospital Hospitals, Xiaotangshan model hospitals after the epidemic can be used and maintained normally, and can be gradually transformed into long-term standby.

1.4.3 "Public Health Clinical Center" emergency mode (Shanghai)

During the SARS period in 2003, only 8 people in Shanghai, which had 17 million people, were infected, and the prevention and treatment effect was very good. After the outbreak of SARS, Shanghai further improved the treatment capacity of infectious disease hospitals, relocated Shanghai Infectious Disease Hospital as a whole to Jinshan District, and built a permanent "Xiaotangshan Hospital", named "Shanghai Public Health Clinical Center".

The Shanghai Public Health Clinical Center is the largest comprehensive hospital in Shanghai with infectious diseases as the mainstay and other departments as the support. It is also the hospital with the most negative pressure beds in the country. As many as 327 negative pressure ward beds can not only guarantee The centralized quarantine treatment during most epidemic situations can also ensure that the severely ill patients are provided with very good treatment conditions during severe epidemic situations. Moreover, at the beginning of the construction of the Shanghai Public Health Clinical Center, expansion plans have been reserved. After the occurrence of the new crown epidemic, Shanghai announced on February 10 that it had launched a project expansion plan to further enhance its treatment capacity.

Nanjing's approach to benchmarking Shanghai. In 2013, it plans to build a Nanjing Public Health and Medical Center dedicated to responding to major public emergencies, with 900 beds, mainly for the treatment of infectious diseases, supported by other departments.

Shanghai Public Health Clinical Center [source network]

After the outbreak of the new crown epidemic, emergency capacity expansion was carried out urgently. In only 20 days, the expansion of 72 isolation wards and 32 medical and nursing rooms was completed.

The Chengdu Municipal Public Health Clinical Medical Center, like Shanghai and Nanjing, has adopted a similar approach. Compared with general infectious disease hospitals, the public health clinical center has a stronger ability of admission and treatment. It integrates multiple functions such as scientific research, prevention, treatment and teaching. Infectious diseases are outbreaks and can be expanded urgently when needed. However, public health clinical centers can only be built in megacities and have basic maintenance for daily operations.

1.4.4 The temporary emergency mode of requisition and reconstruction of existing hospitals

In the current covid-19 epidemic, except Wuhan, Xiaogan and Huanggang are the most severe in Hubei Province. The number of diagnosed people is about 3,000, which is 500 more than the number of people infected with SARS in Beijing in 2003. Its medical level lags far behind Beijing and Wuhan, and there are very few beds for infectious disease treatment. How can we effectively respond to the epidemic? The main measures taken by Xiaogan and Huanggang are rapid renovation and upgrading of existing hospitals. For example, Huanggang requisitioned Dabie Mountain Regional Medical Center as a centralized treatment point for fever patients. Xiaogan requisitioned and reformed four existing hospitals in the early stage, adding 990 beds.[4]

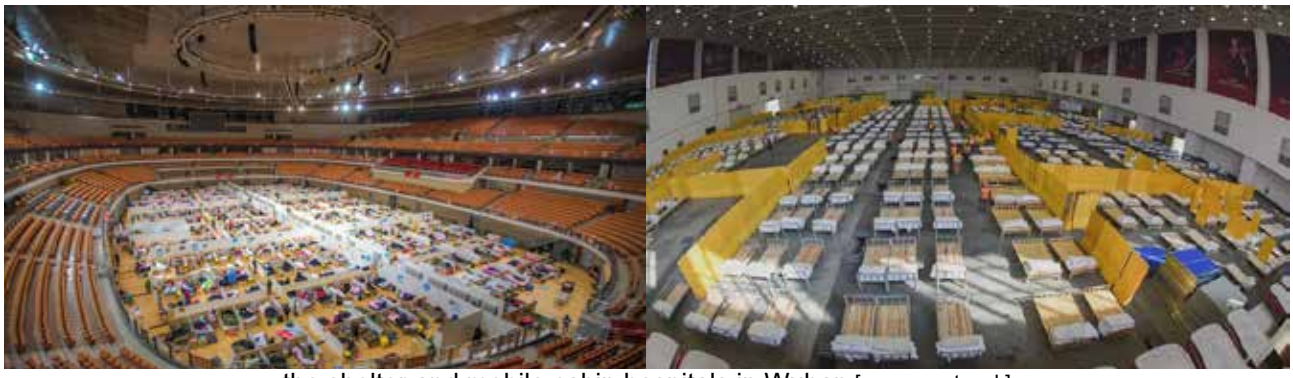
In general cities, whether it is to build a permanent large infectious disease hospital or to quickly build Xiaotangshan Hospital during an epidemic, there are certain difficulties. Rebuilding existing hospitals is a good emergency practice. However, the biggest difficulty in expropriation and transformation is how to balance the treatment of patients with new crown epidemic and ordinary patients. Beds in hospital wards are relatively tight on a daily basis. To be temporarily transformed into an infectious disease treatment hospital during an outbreak, beds must be vacated. How to arrange and transfer a large number of ordinary patients, and how to ensure effective treatment for critical patients, this requires overall consideration.

Dabie Mountain Regional Medical Center [source network]

1.4.5 Transforming the stadium and convention center into a temporary emergency mode for the shelter and mobile cabin hospital

Most of the shelter hospitals are used in the military, and their mobility is very good. China also used this emergency rescue mode during the earthquake relief work of Wenchuan earthquake and Yushu earthquake. During the peak period of the new crown epidemic, there were more patients and fewer beds. The phenomenon of "patients waiting for beds" was very prominent. The use of many designated hospitals in Wuhan + Huoshenshan Hospital + Leishenshan Hospital still cannot solve the problem of tight beds until the cabin The hospital has been put into use one after another, and the problem of bed tension has been fundamentally resolved.

More than 30 gymnasiums and convention centers in Wuhan have been transformed into square cabin hospitals with more than 30,000 beds overnight, fulfilling the requirements for the collection of patients with new crowns, and ensuring the timely isolation and treatment of tens of thousands of mild patients. It is an exaggeration to say that the square cabin hospital model has completely solved the plight of insufficient treatment beds in Wuhan.



the shelter and mobile cabin hospitals in Wuhan [source network]

The square cabin hospital model, whether it was in the Wenchuan earthquake or the Wuhan epidemic, has played a very critical role. This approach requires further research, application and promotion, and it also needs to be planned and reserved in advance. After the epidemic, every city should pay more attention to the emergency standby function of public places such as stadiums and exhibition centers.

1.4.6 How to choose emergency standby mode in different cities?

Before choosing the emergency standby mode, there should be a few consensuses:

First, the prevention and control of major epidemics of infectious diseases is both local and national. The epidemic warfare is actually carried out by the city as a unit, but a major

epidemic is not a city that can deal with it alone. The national and provincial levels are providing command, coordination, scheduling and internal and external resource barriers. Doctors, nurses, and epidemic prevention materials can be solved with the support of other provinces, but the number of beds can only be solved where the epidemic occurs. Beds are the battlefield where doctors, patients, and viruses fight.

Second, the national level should further improve the top-level planning of infectious disease prevention and treatment, and improve the medical treatment system for infectious diseases. It is necessary to clarify the basic support role of infectious disease specialist hospitals and general hospitals for infectious disease areas, as well as the emergency standby hospital for infectious diseases. The key emergency standby role. The two complement each other and promote each other.

Third, the provincial and municipal levels should combine the urban population, economic level, existing infectious disease treatment capabilities, and comprehensive equality of medical water. It is necessary to improve the daily treatment ability of infectious diseases, and must also make adequate emergency backup measures. . It is necessary to adhere to the precautionary principle and to prevent the unprepared war.

Fourth, we must recognize a real situation. Many urban infectious disease specialist hospitals have encountered many difficulties in the actual operation. On the one hand, the infectious disease hospital construction requirements, medical waste disposal and other maintenance costs are high, on the other hand Specialized hospitals for infectious diseases are far away from the city center, and patients with infectious diseases are the first choice for urban general hospitals. As a result, specialized hospitals usually have fewer patients, have a higher bed vacancy rate, and have difficulty operating the hospital. In order to survive, many infectious disease hospitals have to gradually transform into multidisciplinary comprehensive hospitals, which has led to a further reduction in the number of infectious disease treatment beds.

According to the above four points of understanding, every city must have not only the daily treatment capacity for infectious diseases, but also the strong backup emergency treatment capacity.

The five emergency standby modes for infectious disease hospitals are divided into new construction, expansion and reconstruction in project construction, temporary, permanent and semi-permanent in use time, and active emergency and passive emergency in defense awareness. Among them, the "combination of peace and war" mode of public health clinical centers and general hospitals is an active emergency backup measure, while the new Xiaotangshan Hospital, temporary renovation of the original hospital, and temporary transformation of the shelter cabin hospital are passive emergency backup measures. From the perspective of anti-epidemic initiative and effectiveness, active emergency measures should be given priority, and passive emergency measures should be supplemented.

For cities with large populations and provincial capitals, large populations, strong mobility of people, and strong economic strength, a large public health clinical center should be built first, or the existing infectious disease specialist hospital ’s treatment capacity should be further enhanced. Economic strength can support and guarantee the normal operation and long-term standby of public health clinical centers or large specialized hospitals.

For non-provincial capital cities with a population of more than 1 million: focus should be placed on strengthening the treatment capacity of one or two specialized infectious disease hospitals. Infectious disease specialized hospitals are the basic guarantee of the battle. They can be used to isolate and treat patients at the beginning of the epidemic, and critical patients can be protected during the peak period Good treatment conditions.

For other cities with underdeveloped economy: build a specialized hospital for infectious diseases as much as possible under conditions, or rebuild and expand on the basis of the existing general hospital infectious department as a municipal infectious disease treatment institution can be the best solution.

In addition to the basic safeguards for the treatment of infectious diseases, all cities should use the "combination of peace and war" model as the main emergency backup measures. Select some large comprehensive hospitals with strong strength as emergency reserve hospitals for infectious diseases, and make appropriate transformations according to the construction requirements of infectious diseases. Normally, the beds will be opened to ordinary patients to carry out regular emergency epidemic prevention exercises. Infectious disease patients.

The combination of "peace and war" can not only ensure the normal operation of general hospitals, but also ensure that a large number of hospital beds can be provided during pandemic situations. However, to adopt the combination of "peace and war", it is necessary to manage the temporary transformation of the hospital's internal functions. We must achieve a clear understanding of which parts of the hospital are emergency backup areas for infectious diseases, which parts of the hospital are responsible for receiving ordinary patients referred, and which parts of the hospital are responsible for normal operation to ensure the normal treatment of uninfected patients.

With the basic protection of infectious disease areas in infectious disease special hospitals and general hospitals, plus the combination of peacetime and emergency standby mode, combined with defense + treatment measures, if it is not a key outbreak area (such as Wuhan, Xiaogan, Huanggang), most Cities can basically cope with outbreaks of infectious diseases of general scale.

For the key epidemic areas, some temporary emergency measures will be taken as supplements, and according to the actual situation, measures such as the construction of Xiaotangshan Hospital, the renovation of the original hospital, and the transformation of the shelter hospital will be taken.

These five types of emergency backup modes can be used individually or in combination. According to the epidemic prevention level of the local city, and in accordance with the principle of hierarchical and hierarchical management, emergency standby measures are started at different times.

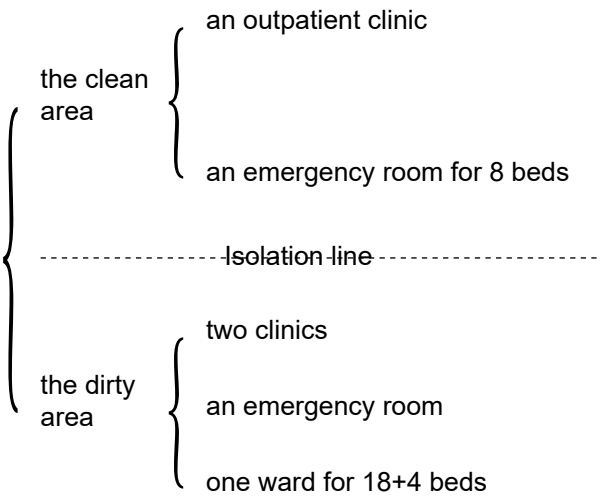
1.5 Research status of emergency hospitals

1.5.1 Functional transformation in Ospedale San Giovanni Bosco(Turin,Italy)

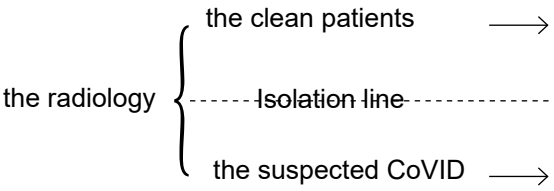
Since Italy is now in a difficult period to fight covid-19, it is easier for us to find a record of Ospedale San Giovanni Bosco at that time to analyze the function transformation mode of Italian hospitals in response to this difficult period.

Here are some of the descriptions of how this hospital is transforming its general functions to deal with infectious diseases:

" Now the clean area has an outpatient clinic and an emergency room for 8 total beds, while the dirty one has two clinics, an emergency room and a hospital room for 18 + 4 total places. The paths are completely separate and also the radiology has two spaces, separated by nylon walls, one for the clean patients, the other for the suspected covid-19. Patients are sorted at pre-triage (the famous tent) and access from two different entrances. The two sections of the PS have no contact except by phone or radio to limit the waste of material as much as possible. the supply of medicines remains in the clean, while in the covid-19 area there is an emergency trolley with only essential pharmacy." [6]

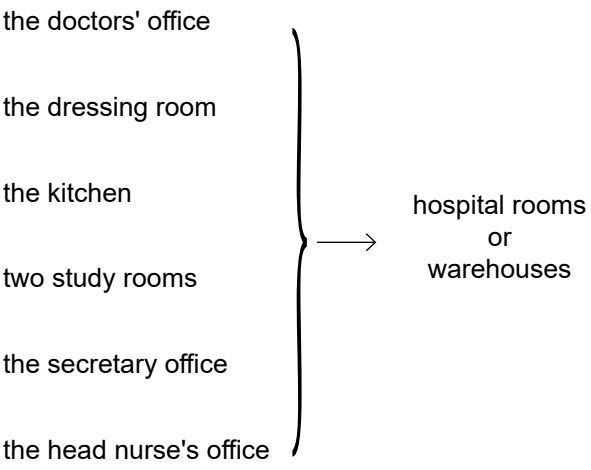


"Outside the isolation room there is the "filter", a free and semi-clean area with a nurse who manages the radio and is in charge of providing the covid isolation room with everything he needs. The filter acts as a link between the clean emergency and the covid isolation emergency and between the covid hospital stay and the rest of the hospital. Washes patients whose swab has tested negative and who need hospitalization in clean areas of the hospital, sanitizes all the material that comes out of the insulation and prepares it for subsequent use, sends test tubes for examination and reads the reports on the radio." [6]



"A line appears on the ground drawn with scotch tape: the right half of the corridor is a dirty area: you can pass from one room to another back and forth with the illusion of keeping the other half clean." [6]

"Two warehouses remained outside the new door, the doctors' room, the doctors' dressing room and the nurses' bathroom. All the rest of the ward,



including the kitchen and the two studies, that of secretary and head nurse and that of the primary, have been emptied and transformed into hospital rooms or warehouses." [6]

"From the second day a line appears on the ground drawn with scotch tape: the right half of the corridor is a dirty area: you can pass from one room to another back and forth with the illusion of keeping the other half clean." [6]

"The whole hospital is helping us out. One hundred internal medicine beds have been converted to low intensity covid places, general surgery has become a covid department, 10 beds in the urology department have turned into a sub-intensive one (to be added to our 14), two floors of rooms Operating rooms house 14 resuscitation beds (110% more than the pre-covid-19 era) and 30 beds have even been obtained in the church." [6]

100 internal medicine beds
→ low intensity covid places

general surgery
→ covid department

10 beds in the urology
→ to be added to 14

two floors of Operating rooms house 14 resuscitation beds (110% more than the pre-covid era)

30 beds have even been obtained in the church.

From this doctor's logbook we can see how hospitals have changed in response to the covid-19 outbreak.On the whole, the hospital immediately transferred the general patients, separated the hospital into a clean area, a semi-clean area and a polluted area, transformed the office kitchen and other space into a ward, and installed a lot of beds.

In fact, we can also clearly see the results after the renovation of the hospital, and these measures also partly protect the health care workers' own safety.

1.5.2 Amsterdam Cancer Centre (Amsterdam,Netherlands)

Amsterdam cancer centre [7]

Site area: 2,000 m2
Building area: 2,000 m2
Total floor area: 6,000 m2
Year of completion: 2006
Quantity of Containers: 256

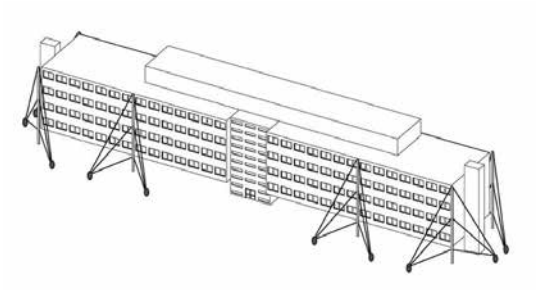
This is a temporary building.It was designed to house the Amsterdam cancer center, which is part of the Antoine van Leeuwenhoek hospital.It is located in Amsterdam, near to the A10 motorway, one of the busiest motorways in the Netherlands. [7]

The original house was no longer fit it, so it was decided to tear it down and reconstruct. Due to the lack of alternative temporary space, continuous facilities need to be provided during the construction phase.Thus, the building raises awareness of the cancer center by creating a unique vertical spatial structure.Each container was painted to advertise the hospital's presence to passing cars on the highway.

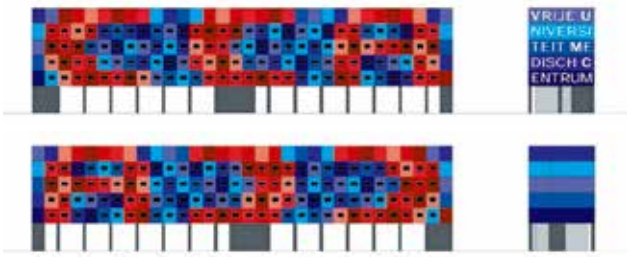
Undoubtedly, this is an excellent use of containers, and once the containers are ready, their combined hospitals can be easily moved from one place to another, even thousands of kilometers away.This building pattern can alleviate the shortage of medical equipment in the case of epidemic diseases.

hoisting container [7]

cancer centre [7]



aerial view of the cancer centre [7]



cancer centre elevation [7]

1.5.3 Sammy Ofer Fortified Underground Emergency Hospital(Haifa,Israel)

Rambam hospital [8]

After missiles fired from Lebanon landed in Haifa in 2006, the leadership of Rambam wanted to ensure the safety of patients and staff.They hoped that they would never again be exposed to enemy fire. In 2014, Rambam opened the Sammy Ofer Fortified Underground Emergency Hospital, the largest of its kind in the world, with a fully equipped medical facility with 2,000 beds.[8]

The hospital was used in peacetime as

an underground car park.It's ready to change in 72 hours.Basic medical services can be provided during special times such as wars or epidemics.Its three floors are equipped to accommodate operating theatres, intensive care units, delivery rooms, dialysis centers, and a large purification center to treat patients exposed to unconventional weapons.

Northern Israel's largest hospital, Israel's largest underground, covers an area of hospital in northern Israel defense headquarters, the sixth naval fleet, and the United Nations peacekeeping force in designated hospitals, 40 km from Israel's northern border, the hospital building extends to 16.5 meters deep underground, 1500 parking Spaces underground three-tier, can into 2000 emergency beds in 3 days, three days to supply energy and material, structure to deal with traditional and non-traditional safety facilities of the war.

sammy ofer fortified underground emergency hospital [8]

Chapter 2
Research on prefabricated hospital (a case study of Leishenshan hospital in Wuhan)

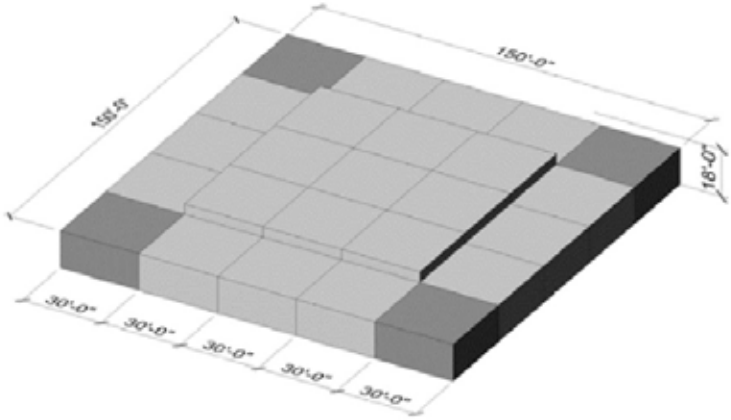
2.1 The significance and application of prefabricated hospital

Prefabricated construction have developed rapidly in China. In recent decades, from residential and industrialized buildings,it has gradually expanded to all types of buildings. It has the characteristics of high construction quality, short construction period, and less environmental pollution, which makes this form of construction develop rapidly.

2.1.1 Hospital module system

In March 2011, Chinese architect Lee Burkhart Liu designed a comprehensive medical institution suitable for 75 beds-225 beds in the United States. It is a building integrating testing, treatment, rehabilitation, experiment, surgery and research. Its variability and sustainability features provide good ideas for the expansion and reconstruction of future hospital buildings.

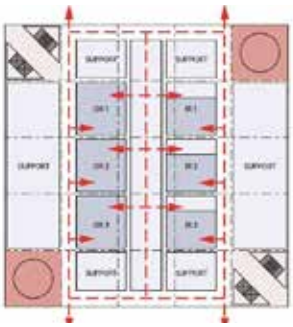
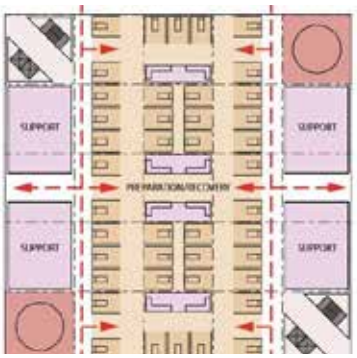
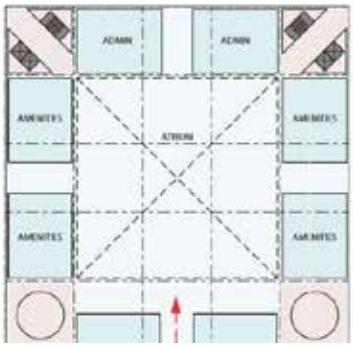
Architect Lee Burkhart Liu first designed a 150x150 (45mx45m) rectangular universal unit for the hospital, with a grid size of 30x30 (9mx9m).



Basic dimensions of modular unit [9]

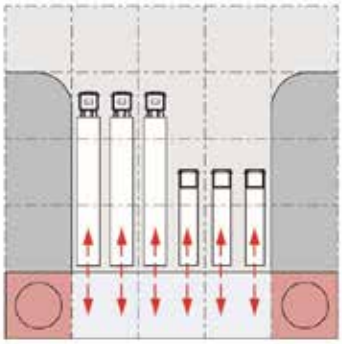
In March 2011, Chinese architect Lee Burkhart Liu designed a comprehensive medical institution suitable for 75 beds-225 beds in the United States. It is a building integrating testing, treatment, rehabilitation, experiment, surgery and research. Its variability and sustainability features provide good ideas for the expansion and reconstruction of future hospital buildings.

Architect Lee Burkhart Liu first designed a 150x150 (45mx45m) rectangular universal unit for the hospital, with a grid size of 30x30 (9mx9m).This basic module is divided into modules containing different building functions according to the requirements of the hospital. The module should not only take into account the existing use requirements, but also reserve general space according to the specific requirements of future renovation and expansion, equipment update and so on.The following figure shows 14 modular units with hospital functions:

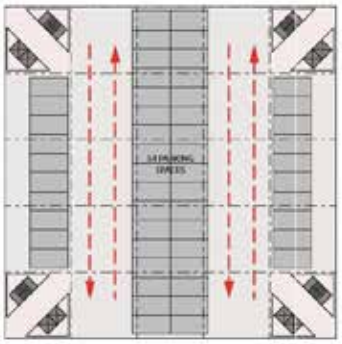
 nursing 24-bed nursing unit (ACU) or 2 groups of 12-bed intensive care unit (ICU)	 interventional suite Surgery Center, includes 6 operating rooms and a central supply hall	 MOB-clinic Outpatient treatment center, includes two treatment departments and two counseling offices
 MOB-office The office area of medical staff in the hospital and the outpatient registration management office	 combined ED/imaging Hybrid emergency treatment center and medical technology department module for small hospitals	 combined interventional Mixed operation center and recovery test room for small hospital
 pre/recovery-PACU Standard large-scale preoperative preparation and post-operative recovery center	 laboratory Standardized laboratories, mainly serving the pharmacy department, pathology department, surgical laboratory department and biochemistry department	 entry pavilion Hospital reception hall, providing registration, fees, reception, medical guidance, life shopping and other services for outpatients / inpatients

14 modular units with hospital functions [9]

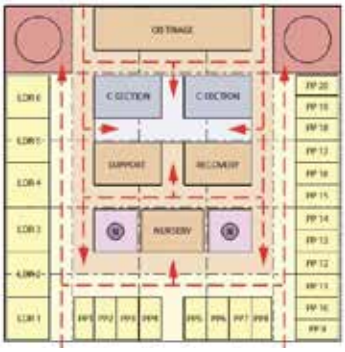
conference



Loading dock



parking



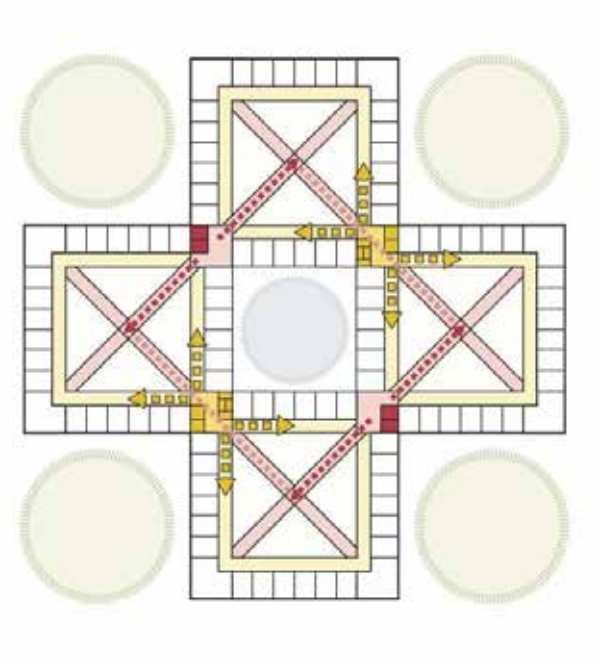
LDR

Childbirth Center: Unlike LDRP, surgical recovery and separation of children ’s rooms refer to different areas

14 modular units with hospital functions [9]

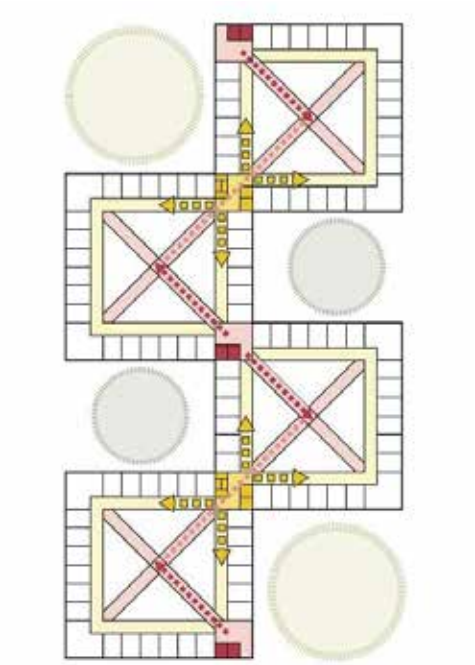
2.1.2 Organizational layout of modules

The arrangement and combination of modules is the core of architectural space layout design. Among them, the most demanded is the combination of ward units, because the ward units must ensure the lighting efficiency of each room. Taking the combination of ward unit modules as an example, it can be divided into four categories: Crossing, Alternating,Dogleg and Diagonal.



(1) Crossing [9]

This is the most basic combination type. It has high efficiency, short traffic flow and

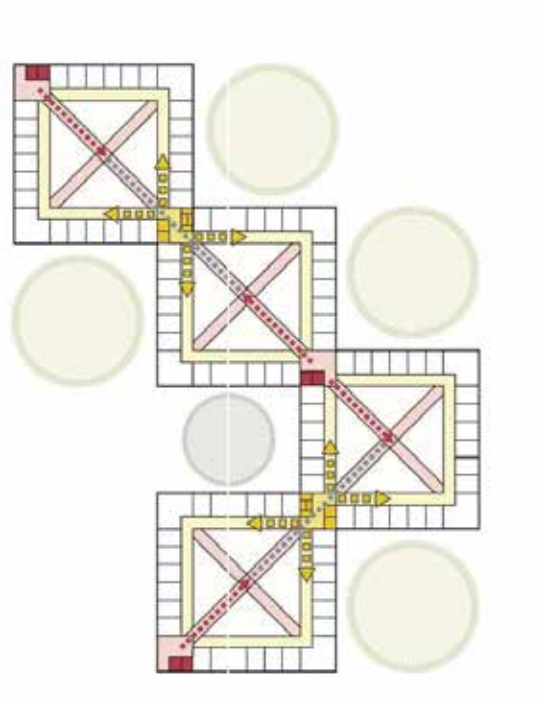


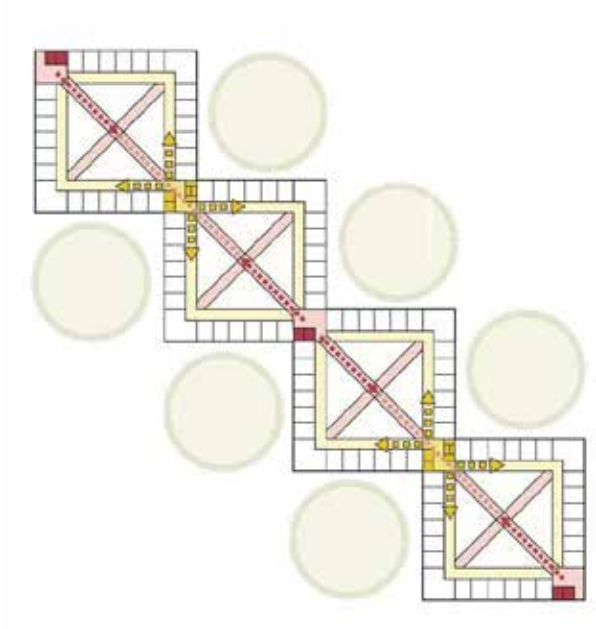
(2) Alternating [9]

his is through the wrong movement of the module to complete the lighting of the

concentrated area. One quarter of the ward space is lit by the inner court, and the traffic units are arranged at the four corners of the inner court, ensuring that one module has two traffic units.

ward space. All wards are facing the outer garden; the patients and their families do not enter the oblique medical staff passage.





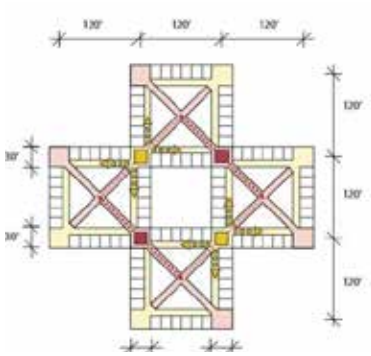
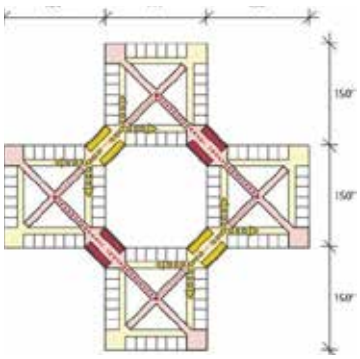
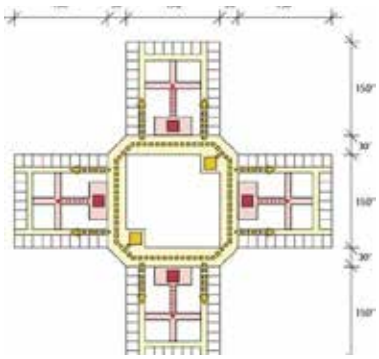
(3) Dogleg [9]

It is a set of oblique L-shaped modular combination mode, all wards are facing the outdoor garden; the traffic flow is relatively chaotic, and the sense of direction is relatively poor; the combined mode has a high area requirement and has special requirements for the site environment. Land use efficiency is low.

(4) Diagonal [9]

The oblique combination type is a combination mode in which the modules are connected diagonally, and all wards can directly face the outdoor garden, with the best view and the widest view; the traffic flow lines are clear and the direction is clear, but the flow lines are too long; the combined mode covers an area The demand is higher, the requirements for the site are the highest, and the land use efficiency is the lowest.

There are three ways to connect the modules: Overlap, Touch and Separate. Standard modules leave a 30ftx30ft space in the corners to ensure the diversity of the connecting module passages. Depending on the connection method of the module, the form of the connected passages also varies.

overlap	touch	separate
		
This type of channel has a small space and cannot be used as the core of transportation to solve the problem of up and down traffic.The advantage is that it saves land area and is aimed at small community hospitals with small plots.	When the modules intersect, they are connected by diagonal passages. Stairs and elevators can be placed on both sides of the diagonal channels, as well as some logistics rooms. Relative to the overlap, the flexibility is higher. Large, medium and small hospitals are available.	When the modules are separated, the interconnection can be connected with a ring channel, which is aimed at large hospitals with unrestricted land.

three module channel type characteristics [9]

2.2 The construction background of Wuhan Leishenshan hospital

2.2.1 The impact of covid-19 on Wuhan city

At the start of 2020, a covid-19 broke out in city Wuhan, China. As the number of infected people increased, the Chinese government decided to establish two hospitals in Wuhan in the fastest and most effective way to treat infected patients. About 40,000 builders completed the Leishenshan hospital and Huoshenshan Hospitals during about 10 days. Many local museums and exhibition halls have also been requisitioned for isolation treatment of mild patients.

On March 19, it is first day that Chinese officials announced that there were no new patients of Wuhan, and there were no local new cases in China; On April 15, 68 days after commissioning, the ward of Wuhan Raytheon Hospital was closed. This special hospital built to fight against the new coronary pneumonia epidemic has completed its mission and has admitted a total of 2011 patients during its operation. Facts have proved that these two hospitals played a very important role during the fight against the epidemic. This thisis will analyze one of the two hospitals in detail-Leishenshan Hospital.

2.2.2 Wuhan city analysis

the geographical position of the site in China

Wuhan, known as the "heart" of China's economic geography, is located in the middle and lower reaches of the Yangtze river and the east of the jianghan plain.Wuhan has seven districts in the central city and six in the far city.

Wuhan belongs to the north sub-tropical monsoon (humid) climate, with abundant perennial rainfall, sufficient heat, rain and heat in the same season, light and heat in the same season, cold in winter and hot in summer, four distinct seasons.The temperature in Wuhan is warm in winter and hot in summer, with temperatures ranging from -5℃ to 36℃ .

Wuhan is located in the center of China, connecting eastern and western, southern and northern. It is the transportation hub of China. A number of highways and main railway lines converge in Wuhan.Wuhan Tianhe International Airport is connected by the Wuhan

Airport Expressway and can fly directly to more than 40 international metropolises such as Rome, Paris, London, San Francisco, and Tokyo. Wuhan has always been an important port on the Yangtze River, but with the decline of passenger shipping on the Yangtze River, the current Wuhan passenger port only has tourist charter boats calling.

Wuhan traffic route map [10]

Map of traffic routes around the site [10]

Since Wuhan opened its first subway line in 2004, there are 9 subway lines in Wuhan. It can be seen from the figure that the subway lines are densely distributed in the city center and gradually lead to all corners of Wuhan City, and the public transportation on the ground makes the transportation in Wuhan very convenient.

Wuhan metro line [11]

Wuhan metro line map around the site [11]

Wuhan metro line map [11]

2.2.3 Land planning and hospital information of Wuhan city

项目 Item		诊疗人次（千次）Total Number of Patients Treated (1000 person-times)	入院人数（千人）Hospital Admissions (1000 patients)	病床周转次数（次）Turnover of Beds (times)	病床使用率（%）Utilization Rate of Beds (%)
合计	**Total**	**81155.73**	**2858.74**	**33.80**	**88.17**
一、医院	Hospitals	51843.40	2523.31	34.70	92.51
综合医院	General Hospitals	37439.85	1871.76	37.40	96.73
中医医院	Hospitals of Chinese Medicine	4486.06	174.40	30.80	81.02
中西医结合医院	Hospitals of Chinese and Westen Medicine	3546.37	134.75	29.80	85.44
专科医院	Specialized Hospitals	6371.12	342.40	27.50	83.43
二、疗养院	Sanatoriums	0.00	0.00	0.00	0.00
三、社区卫生服务中心（站）	Community Health Service Centers	9478.99	97.21	17.70	45.47
四、卫生院	Health Centers	3632.46	139.34	33.00	66.24
街道卫生院	Urban Township Hospitals	311.61	13.24	31.80	57.95
乡镇卫生院	Rural Township Hospitals	3320.85	126.10	33.10	67.21
五、门诊部	Out-pactient Department	1729.01	0.80	0.00	0.00
六、妇幼保健机构	Maternity and Child Care Centers	3149.44	87.57	54.30	99.61
七、疾病预防控制机构	Disease Prevention and Treatment Centers	0.00	0.00	0.00	0.00
八、专科疾病防治机构	Specialized Disease Prevention & Treatment Centers	153.28	10.51	20.70	75.20

Statistics on medical institutions(2017) [12]

In 2017, medical institutions in Wuhan received more than 81 million patients, of which the hospital received the most, accounting for 64%. In China, there are four types of hospitals: General Hospitals, Hospitals of Chinese Medicine, Hospitals of Chinese and Western Medicine and Specialized Hospitals. Among them, General Hospitals have the most total number of patients treated and hospital admissioins, but the most turnover of beds and most utilization rate of beds are the Matemity and Child Care Centers.

单位:张 (unit)

项目 Item		2013	2014	2015	2016	2017
合计	Total	66563	72827	80726	87408	91635
医院	Hospitals	55076	60127	67550	74453	78447
卫生院	Health Centers	3469	4077	4226	4443	4530
社区卫生服务中心	Community Health Service Centers	5673	6086	6175	6174	6215
门诊部,所	Clinics	78	77	50	36	32
专科防治所,站	Special Prevention and Treatment Centers or Stations	843	904	959	531	534
妇幼保健所,站	Maternity and Child Care Centers	1424	1556	1766	1771	1877

Numbers of beds in health institutions [13]

According to the statistics, in 2017 there are total 91635 beds in health institutions, only 8.41 people can have beds for 1000 people, and 11.7 staff can provide medical services.

单位:张,人 (unit, person)

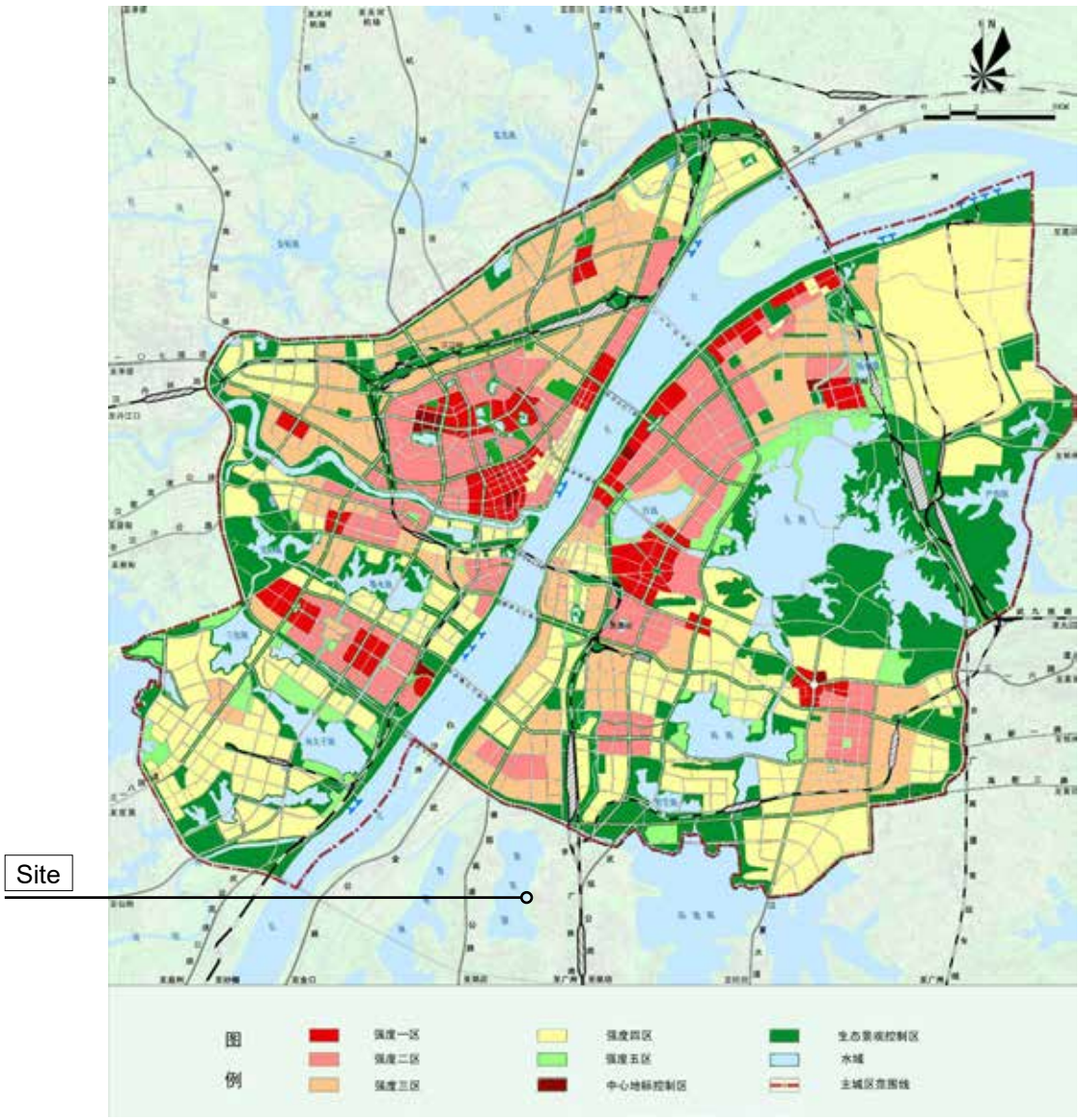
项目 Item	2013	2014	2015	2016	2017
每千人口卫生床位数 Number of Beds per 1000 population	7.12	8.85	7.61	8.12	8.41
#每千人口医院床位数 Number of Hospital beds per 1000 population	6.78	7.31	6.36	6.92	7.2
每千人口卫生工作人员数 Number of Medical Personnel per 100 population	11.02	11.83	10.78	11.42	11.7
#每千人口卫生技术人员数 Number of Medical Technical Personnel per 1000 population	8.78	9.14	8.65	9.13	9.41
每千人口医生数 Number of Doctors per 1000 population	3.33	3.59	3.1	3.23	3.33
每千人口护师,护士数 Number of Senior and Junior Nurses per 1000 population	3.89	4.41	4.26	4.56	4.71

Numbers of beds and persons engaged in medical and health institutions per 1000 population [14]

项目 Item	病名		死亡率1/10万 Death Rate (per 100000 Persons)	构成(%) Constitution
合计 Total	恶性肿瘤	Malignant Tumour	203.96	29
	脑血管病	Cerebrovascular Disease	161.15	22.91
	心脏病	Heart Trouble	133.75	19.02
	呼吸系统疾病	Respiratory Disease	62.96	8.95
	损伤与中毒外部原因	Trauma and Toxicosis	38.69	5.5
	内分泌,营养和代谢疾病	Disease about endocrine, nutrition and metabolic	24.24	3.45
	消化系统疾病	Digestive Disease	16.74	2.38
	神经系统疾病	Nervous System Disease	9.78	1.39
	泌尿生殖系统疾病	Urinary Disease	7.79	1.11
	传染病	Contagious Disease	6.29	0.89
男性 Male	恶性肿瘤	Malignant Tumour	261.67	32.29
	脑血管病	Cerebrovascular Disease	172.9	21.34
	心脏病	Heart Trouble	140.21	17.3
	呼吸系统疾病	Respiratory Disease	79.33	9.79
	损伤和中毒外部原因	Trauma and Toxicosis	46.87	5.78
	内分泌,营养和代谢疾病	Disease about endocrine, nutrition and metabolic	22.74	2.81
	消化系统疾病	Digestive Disease	20.05	2.47
	神经系统疾病	Nervous System Disease	10.08	1.24
	泌尿生殖系统疾病	Urinary Disease	9.21	1.14
	传染病	Contagious Disease	9.03	1.11
女性 Female	脑血管病	Cerebrovascular Disease	148.99	25.15
	恶性肿瘤	Malignant Tumour	144.18	24.33
	心脏病	Heart Trouble	127.08	21.45
	呼吸系统疾病	Respiratory Disease	46	7.76
	损伤和中毒外部原因	Trauma and Toxicosis	30.22	5.1
	内分泌,营养和代谢疾病	Disease about endocrine, nutrition and metabolic	25.79	4.35
	消化系统疾病	Digestive Disease	13.31	2.25
	神经系统疾病	Nervous System Disease	9.48	1.6
	泌尿生殖系统疾病	Urinary Disease	6.32	1.07
	传染病	Contagious Disease	3.45	0.58

The composition of ten main diseases causing death of residents(2017) [15]

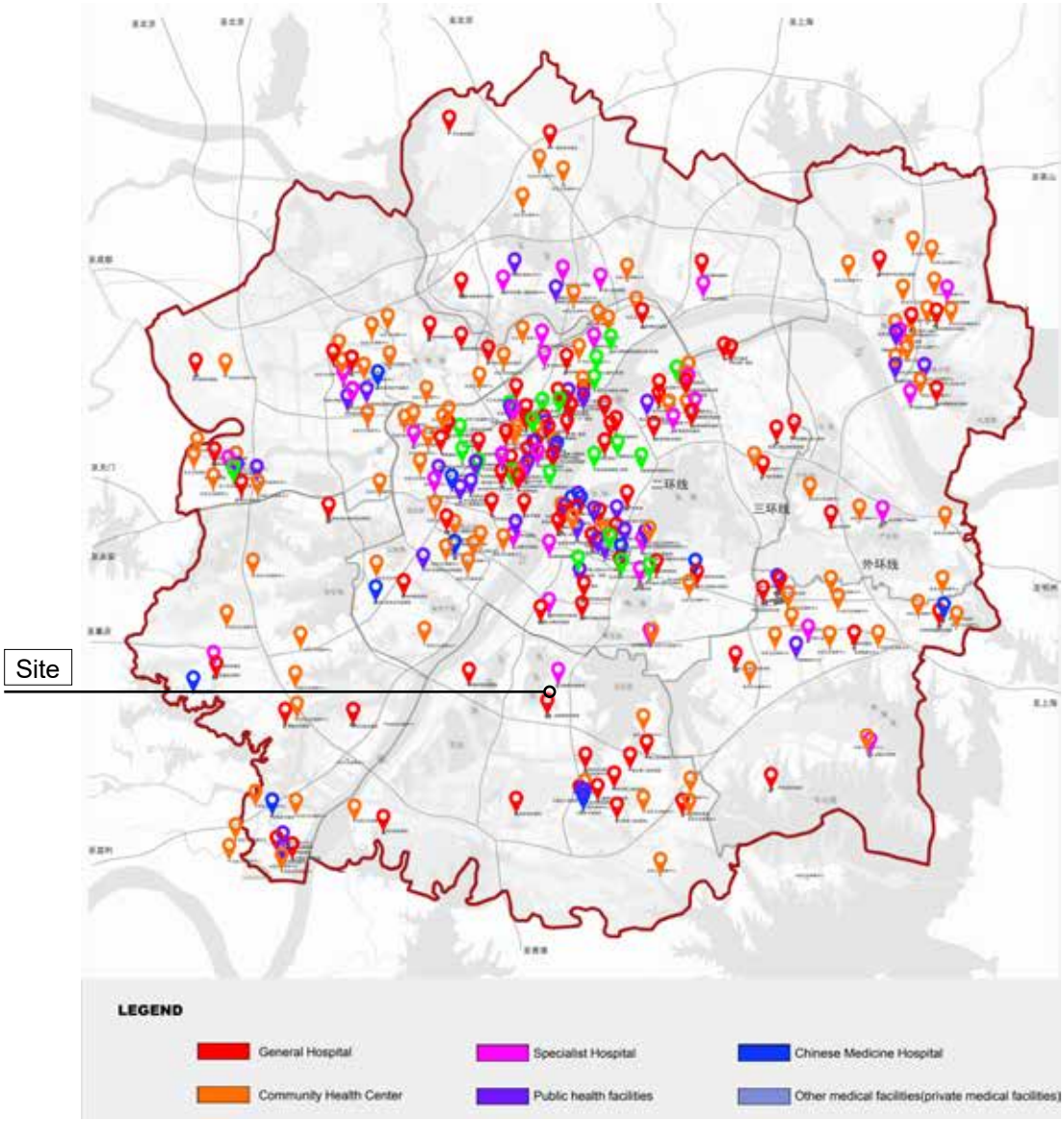
The disease that causes the most deaths among residents is malignant tumour, which is also the disease with the highest lethal rate for men, and cerebrovascular disease for women.



The intensity of landuse [16]

According to *The interim regulations on land construction intensity management in the main urban area of wuhan city (trial)*, The project is located outside the main urban area.

Most of the hospitals in Wuhan are concentrated in the city center, and are generally distributed according to the density of residents. The more residents, the more local hospitals there are, and generally there are various types of hospitals in each area.

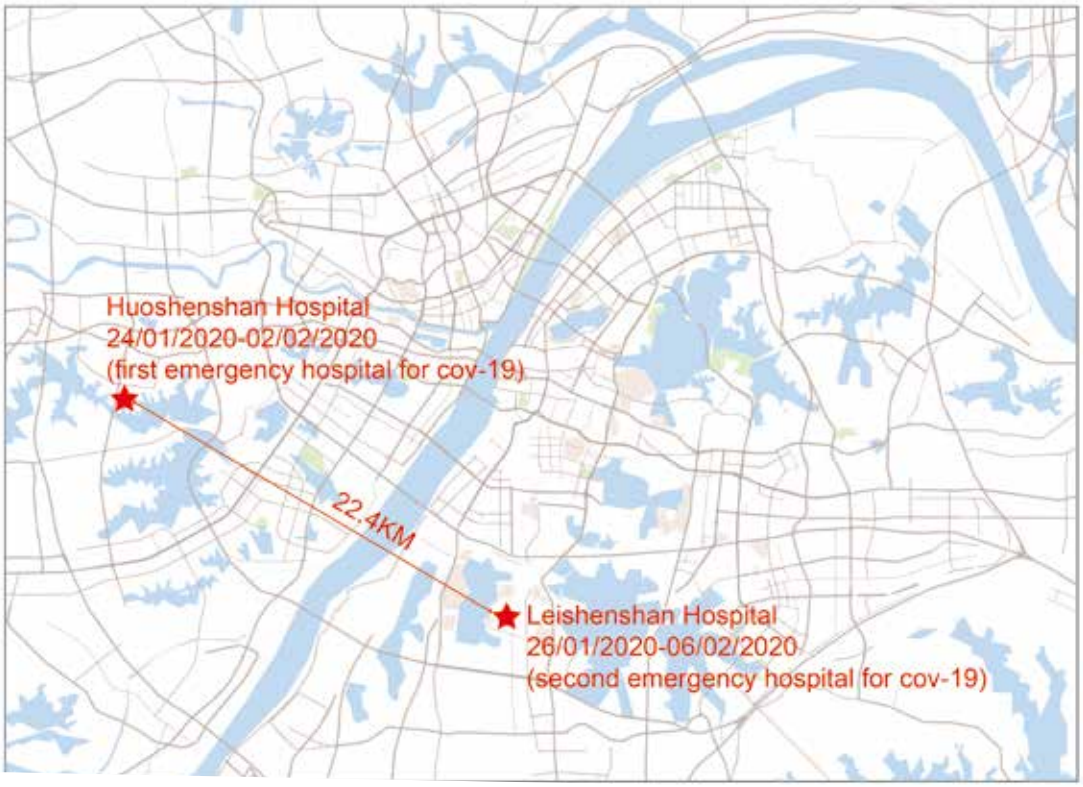


Spatial layout planning of medical and health facilities in Wuhan city

2.3 Wuhan Leishenshan hospital construction

2.3.1 Location analysis of Leishenshan hospital in Wuhan

Wuhan Leishenshan hospital is located at qiangjun road, jiangxia district. The treatment targets are covid-19 patients with fever diagnosed in the outpatient department and inpatient confirmed in each hospital. The hospital fully draws on the experience of "xiaotangshan hospital" during the SARS period, ano only inpatient clinics are set up.On January 29, 2020, Leishenshan hospital was expanded to approximately 60,000 square meters of gross floor area under the latest design. Of these, the medical isolation area is about 51,000 square meters, and the number of beds has been increased to about 1,600, including 1.300 new beds.The medical accommodation area is about 9000 square meters and can accommodate more than 2000 medical staff.



two hospitals distance and construction time

The hospital has a total of 1600 beds, which are 2 intensive care units, 3 sub-critical care units and 27 general units. Except for critical care units, all the wards are 2 beds. The hospital set up an operating room for Covid-19 patients.In addition, the hospital has also set up the department of electrocardiography, ultrasound imaging, imaging, medical laboratory and other medical technology departments to meet the needs of auxiliary diagnosis of COVID-19 patients. The hospital is equipped with CT, bedside ultrasound, automatic biochemical analyzer, Ike membrane bedside blood gas analyzer, non-invasive ventilator, other supporting facilities and equipment, in order to realize CT and ECG remote diagnosis transmission.

Location factors

1. Geographical location
a. Leishenshan hospital is located at huangjia lake, which is under the dominant downwind
b. As it is not the urban water source, the hospital sewage shall adopt underground anti-seepage measures, which will not cause pollution to the surrounding environment.
C. It is located in the suburbs, with a small population and a small impact

2. Transportation:It is close to the main road of the city, and the subway passes by, so the transportation is convenient and it is convenient for the transfer of personnel and materials.

3. Government support:Centralized treatment of COVID-19 patients, with strong support from the country.

4. Land resources:There is enough space for construction, the terrain is flat, and the construction is convenient.

5. Surrounding environment:The surrounding environment is beautiful, which can relieve and stabilize the patient's mood.It pays attention not only to the patient's body, but also to his mental health.

2.3.2 Construction record of Leishenshan hospital

The Chinese government built the hospital in 12 days at an alarming rate from 25 of January 2020 until 6 of February. A live is set up on the construction site, and people all over the world can watch the construction process of the two hospitals in real time through the live broadcast.

25.01.2020

Wuhan epidemic prevention headquarters held a dispatching meeting, decided to build another emergency hospital named Leishenshan in Wuhan.

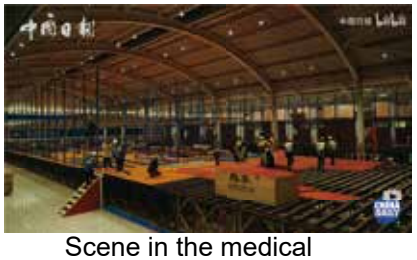
Panoramic view of the construction site [17]

Scene in the medical accommodation area [18]

26.01.2020

At 2 o 'clock in the morning of 26th, more than 60 construction equipment came to the scene and the site leveling and construction began.

28.01.2020



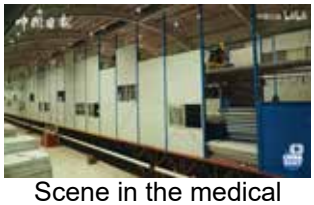
Scene in the medical accommodation area [19]

29.01.2020

In Leishenshan hospital project, the construction of HDPE film under the embedded groove pipeline and board house in the medical isolation area was basically completed, and the strip foundation was over 30% complete. Off-site assembly and modification of the on-site board house were fully started.

The steel structure foundation of the medical accommodation area has been completed. The wall installation of dormitory building 1 , 2 and 7 has been basically completed. The wall of the rest dormitories has been nearly half completed.

H beam steel pier and bar concrete pier [20]



Scene in the medical accommodation area [19]

31.01.2020

As of 12 noon on January 31, the overall construction schedule of the Leishenshan hospital project was 55% complete.

The isolation ward has completed 50%. The site leveling, trench excavation, trench pipeline pre-buried, the construction of PE film in non-trench area, trench backfilling, and the concrete pouring of the floor of sewage treatment station have all been completed.

The surface layer of the main pipeline has been poured 90%, the PE film in the trench area 60%, the strip foundation construction 85%, and the foundation floor of the medical and technical building 60%.

A total of 2,149 containers entered the site, 130 of which have been lifted and pipelines installed in the room have been completed. [21]

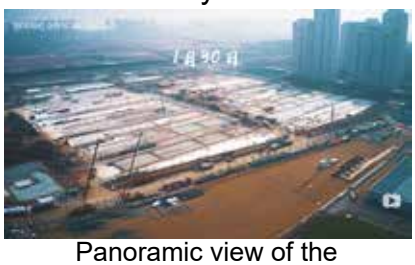
The task of building and retrofitting Leishenshan hospital's communications base station infrastructure will be performed by the operator after installation prior to delivery by the hospital engineering body.

By the end of the day, the pipeline trench excavation and the installation of bailey beam in the medical isolation area of the hospital project were all completed, and the earthwork backfilling and HDPE film construction were started.

30.01.2020

The overall construction schedule of Leishenshan hospital project has completed 40%, the impermeable membrane in the yining isolation area has been basically laid, and the field assembly of 1500 board rooms has been fully started. The next step is to fully carry out the lifting operation of board rooms.

The construction of the board house structure was completed in the 7 dormitories of the medical staff living area, and the installation of water and electricity was carried out simultaneously.



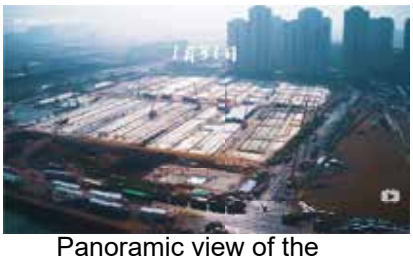
Panoramic view of the construction site [22]

Hoisting of board house [22]

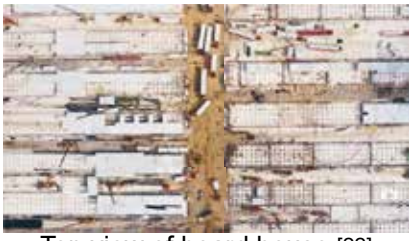
01.02.2020

On February 1, the overall progress of the project of Leishenshan hospital in wuhan completed 65%, and the whole project entered the hoisting stage of the ward.

75% of the medical staff living area is completed (the main structure of A1-A7 building is basically completed, the indoor pipeline installation has been carried out, and the waterproofing of the model room of A1 building has been completed)



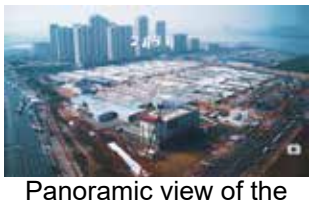
Panoramic view of the construction site [22]



Top view of board house [22]

03.02.2020

By the noon of February 3, the overall progress of the project of Leishenshan hospital in wuhan has completed about 80%. As the "heart" of the hospital, the steel structure of the medical technology building has been lifted successfully, and welding, roof assembly, internal decoration and equipment installation of various functional areas are being stepped up. Among them, the CT equipment used to scan the lungs of patients has entered the site in advance.



Panoramic view of the construction site [22]

View inside the ward [24]

At present, 768 professional management personnel, 5,895 construction personnel, 1,306 excavators, cranes and other mechanical equipment are on site for construction.

In the ward isolation area, a total of 3,300 box-type board rooms are planned to be installed. As of 12 o 'clock on February 1, 2,530 of them have arrived and 310 of them have been lifted. It is planned that nearly 1,000 of them will be lifted on February 1.

At present, the progress of the ward isolation area has been completed by 60%, and the construction of supporting houses such as sewage treatment station, liquid oxygen station, positive and negative pressure station and garbage incineration station is being accelerated.

Hoisting of board house [23]

Panoramic view of the construction site [22]

04.02.2020

By the noon of April 4, Wuhan Leishenshan hospital has completed 90% of the overall progress, and the isolation ward area has completed 85% of the total workload.Among them, 2320 box-type board rooms have been hoisted, and the floor glue construction has been completed to 1,100. The installation and decoration of the rooms have been carried out simultaneously.

Waste treatment station, liquid oxygen station, positive and negative pressure station room, garbage storage room and other equipment foundation completed, sewage treatment station equipment hoisting completed, pipe installation completed 80%, medical and living areas completed 95% of the total workload.

05.02.2020

Construction of Leishenshan hospital entered its final phase on Feb. 5.
The isolation ward area has a total of 3,300 box wards, with 3,093 on site;
The foundation construction of the isolation ward has been completed, 2900 rooms of the box ward have been lifted, the floor glue construction has been completed to 1400 rooms, and the installation and decoration of the room have been carried out simultaneously.

Scene in the medical accommodation area [22]

H beam steel pier and bar concrete pier
[source network]

Medical staff accommodation area

Interior decoration of the medical staff accommodation area

06.02.2020

Construction is completed and patients are admitted.

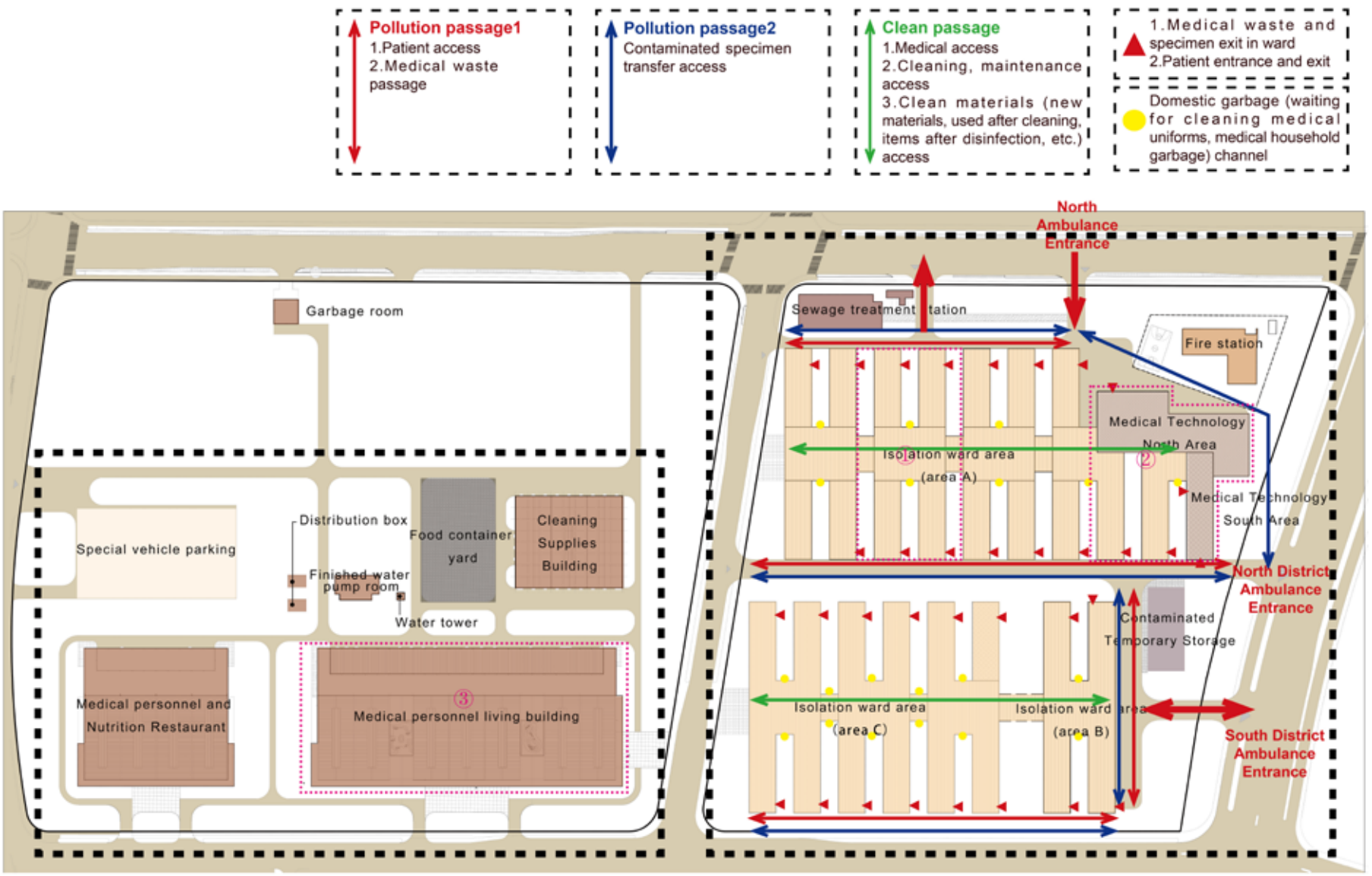
2.3.3 Functional division and human flow of Leishenshan hospital

Hospital isolation treatment is divided into A area, B area, C area.The north section (A section) has 15 isolation wards, 1 pharmacy section, and 1 medical technology section (including ICU, test center, CT, ultrasound, ECG, etc.) located in the east section.The southern area (B, C) has 15 isolation wards, a pharmacy area and an intensive care unit located in the eastern area.The Western Medical Team is linked to the Northern Region through this unit.

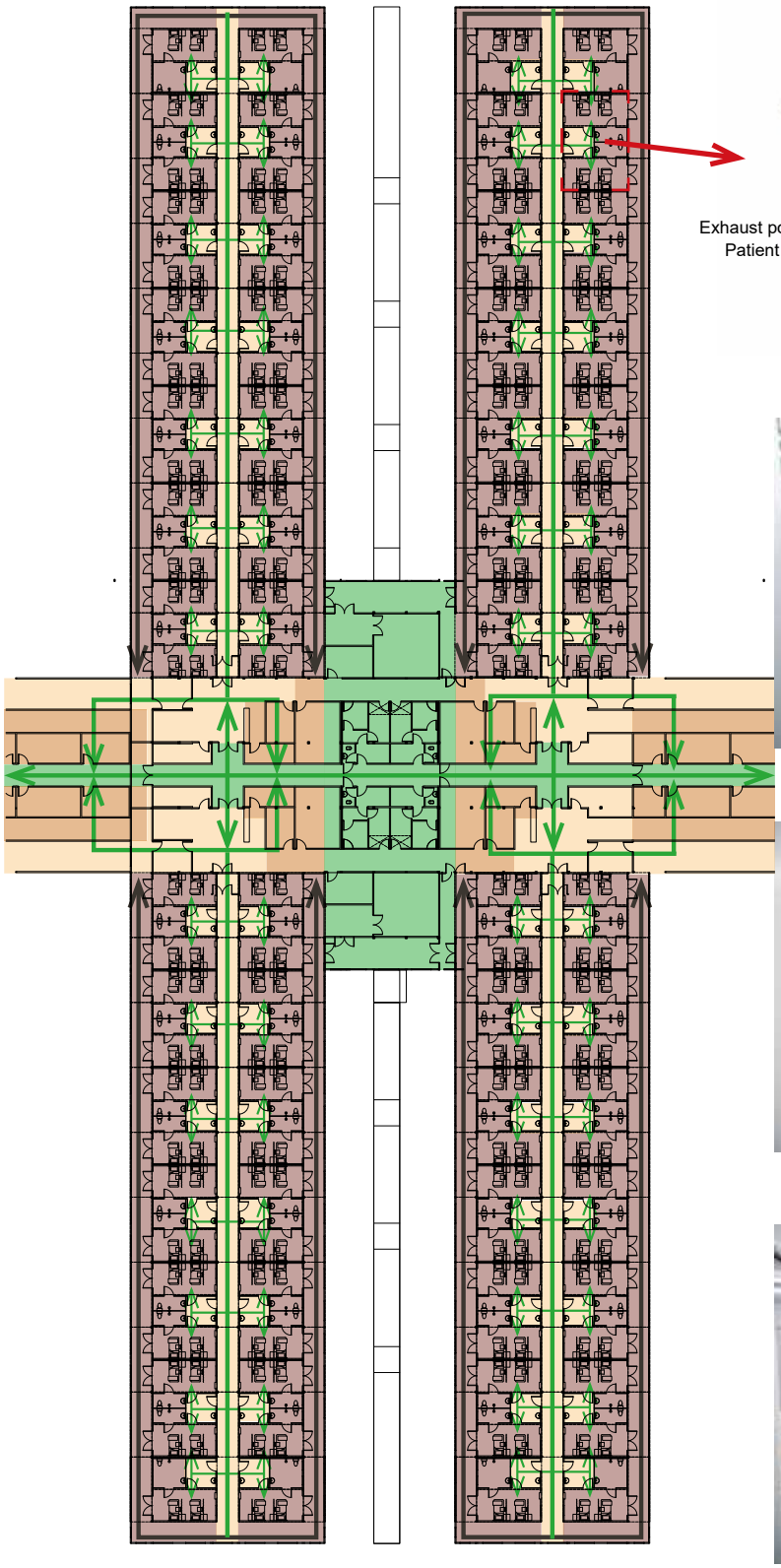
The area where the patients arrive in the disease area and medical technology area is the contaminated area.The independent working area entered by the medical staff after changing clothes and taking a shower is the clean area.The area between the clean area and the polluted area is the semi-polluted area, including the area outside the room of the ward office, consultation, treatment, nurse station and so on.

According to the design principle of three areas and two channels, the medical streamline is placed inside the hospital to ensure that the medical personnel are not infected;The patient flow line is set in the periphery of the hospital and strictly separated from the medical flow line.The main flow lines are: medical care-clean passage-clean passage-isolation ward. Each unit area is provided with dirt rooms, usually placed at both ends, with separate external channels.

The ward area is mainly used to treat severely diagnosed patients. The ward area adopts a two-channel plan layout, with an open patient channel on the periphery and a medical channel in the semi-contaminated area in the middle. There are buffer rooms on the entrance of the ward and on both sides of the medical care channel. There is a toilet in the ward.


Pollution passage1
1.Patient access
2.Medical waste passage
Pollution passage2
Contaminated specimen transfer access
Clean passage
1.Medical access
2.Cleaning, maintenance access
3.Clean materials (new materials, used after cleaning, items after disinfection, etc.) access
1.Medical waste and specimen exit in ward
2.Patient entrance and exit
Domestic garbage (waiting for cleaning medical uniforms, medical household garbage) channel
North Ambulance Entrance
Garbage room
Sewage treatment station
Fire station
Medical Technology North Area
Isolation ward area (area A)
Medical Technology South Area
Special vehicle parking
Distribution box
Food container yard
Cleaning Supplies Building
Finished water pump room
Water tower
North District Ambulance Entrance
Contaminated Temporary Storage
Medical personnel and Nutrition Restaurant
Medical personnel living building
Isolation ward area (area C)
Isolation ward area (area B)
South District Ambulance Entrance
MEDICAL PERSONNEL LIVING AREA
QUARANTINE MEDICAL AREA

□ Isolation ward area



Ward unit functional diagram [25]

medical staff passage [24]

ward area [24]

buffer room [24]

Polluted area

Semi-polluted area

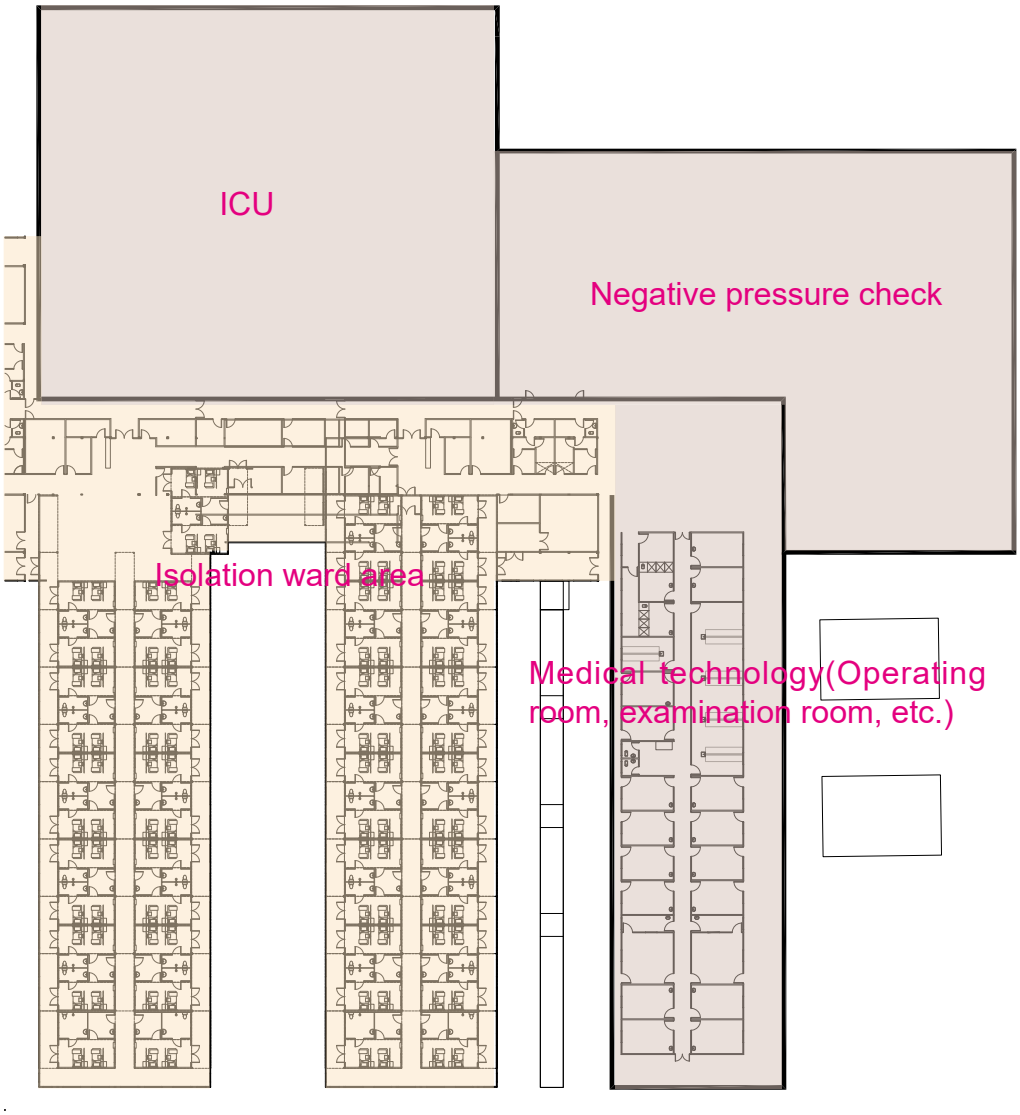
Cleaning area

Clean pass

Medical staff flow

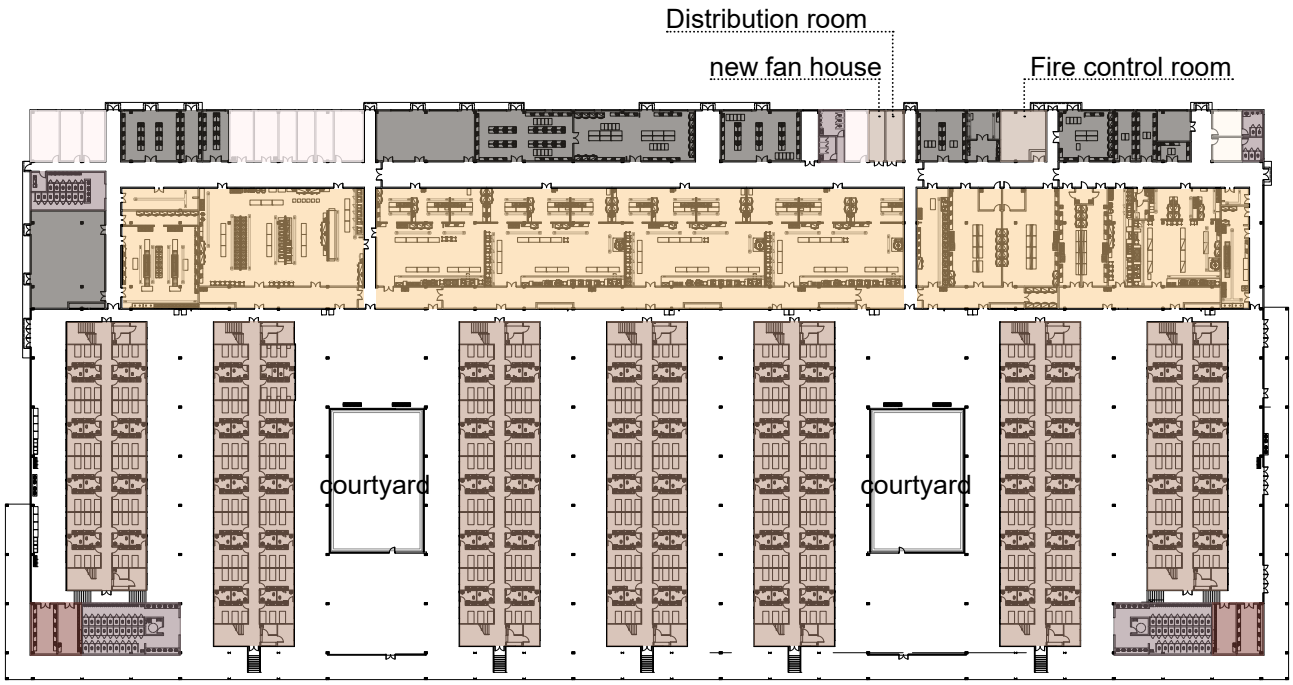
Patient flow

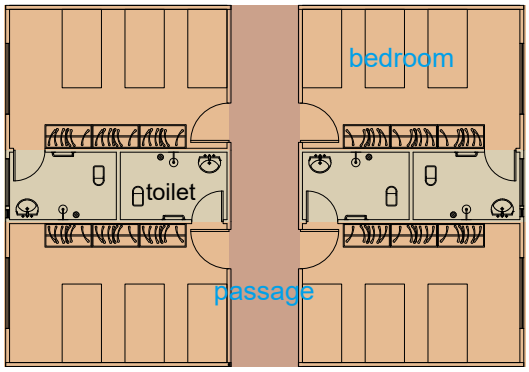
 Isolation ward area and medical technology area



The medical technology area mainly includes negative pressure ICU, negative pressure testing room, negative pressure operating room, DR room, ultrasound room, electrocardiogram room, ultrasound room and other ancillary rooms. The hospital's medical technology is divided into 3 areas. Area A mainly includes negative pressure ICU (approximately 755m2), negative pressure test room (approximately 380m2) and doctor's rest room. Area B includes operating room (approximately 40m2) and DR , B-ultrasound room, electrocardiogram room, ultrasound room and reading room, etc .; Area C is negative pressure ICU (area about 850m2).

Medical personnel living area

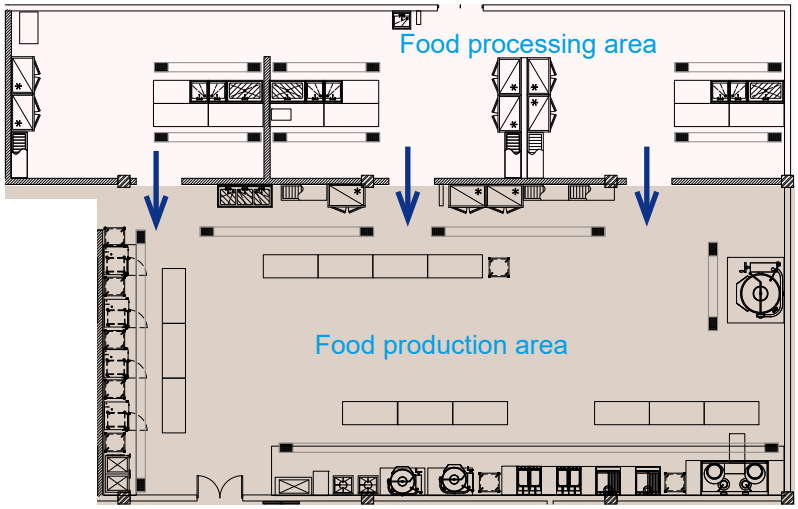




Medical staff living room

medical staff bedroom [26]

Equipment room
office
clean room
food processing room
storage room
toilet
locker room

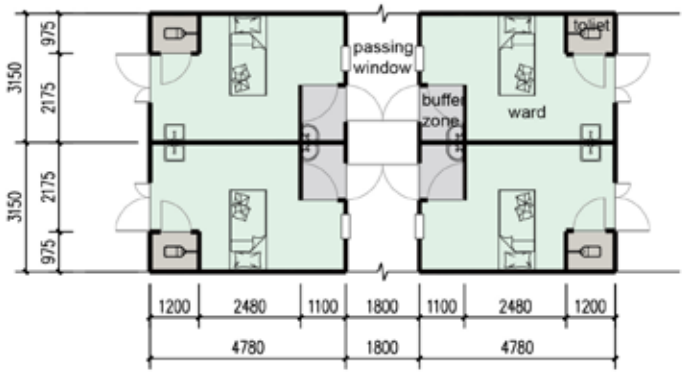


food processing room

Medical staff living room structure [27]

2.3.4 Unit plane and structural analysis of the ward

- Unit plane of single ward room to twin room



single ward unit for 1200 beds

Single ward room area: 14.98 m²
sleep zone area: 12.27 m²
toliet zone area: 1.17 m²
buffer zone area: 1.54 m²

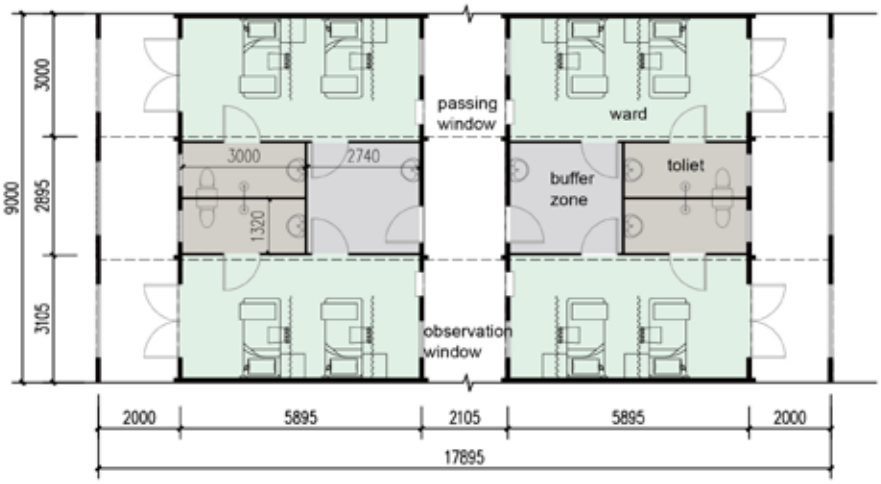
Initially, Raytheon hospital was designed to accommodate 1,200 beds, including some single rooms. But considering the number of patients admitted, the final design was increased by 400 beds to reach the capacity of 1,600 beds, and the single room was changed to a two-bed ward.

- Construction scale

A total construction area of 79000 square meters, total beds: 1600 copies, for 2300 people, including supporting health care occupancy.

-Site condition and foundation form

The soil condition of the site is good, with some reinforced concrete floor available.Strip foundation, buttress and raft foundation are adopted.



twin ward unit for 1600 beds

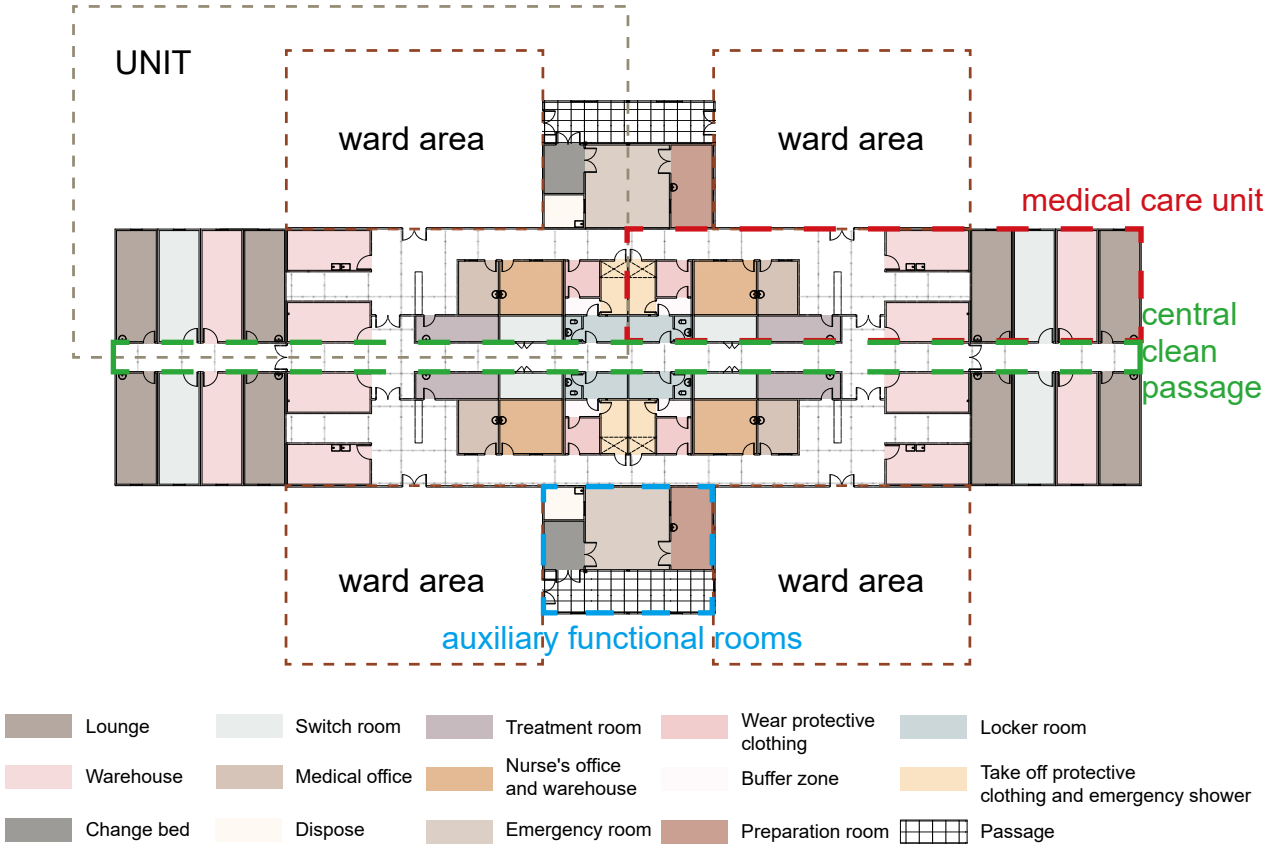
Twin ward room area: 25.02 m²
sleep zone area: 17.37 m²
toliet zone area: 3.96 m²
buffer zone area : 7.37 m² for two rooms

- Structural characteristics

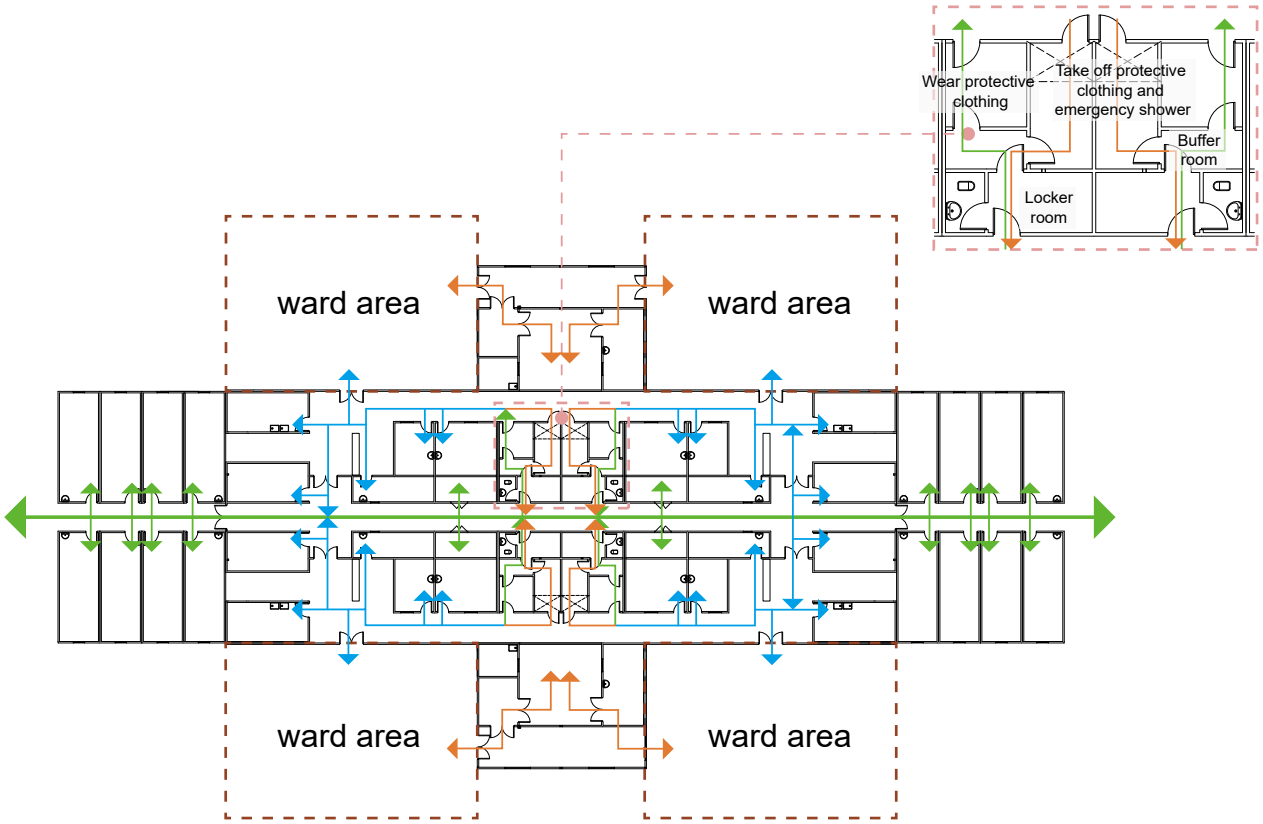
The isolation area has 1 floor, and the medical care area has 2 floors. The assembly type and standardized unit are adopted. The isolation area adopts box-type light steel structure modular house and steel frame structure, while the medical care area adopts light steel movable board house.

- Function of medical working area

The medical care area is mainly composed of three parts: the central clean passage, the medical care unit, and the auxiliary functional rooms. The central clean passage connects various medical care areas and clean rooms (consultation, rest and warehouse); the medical care unit is the office space of medical workers (with nurse stations, doctors offices, etc.), and is connected to the isolation ward unit through the medical aisle and buffer room; The auxiliary function rooms are clean warehouse and medical care lounge. Each medical area contains 4 medical care units.



function of medical working area

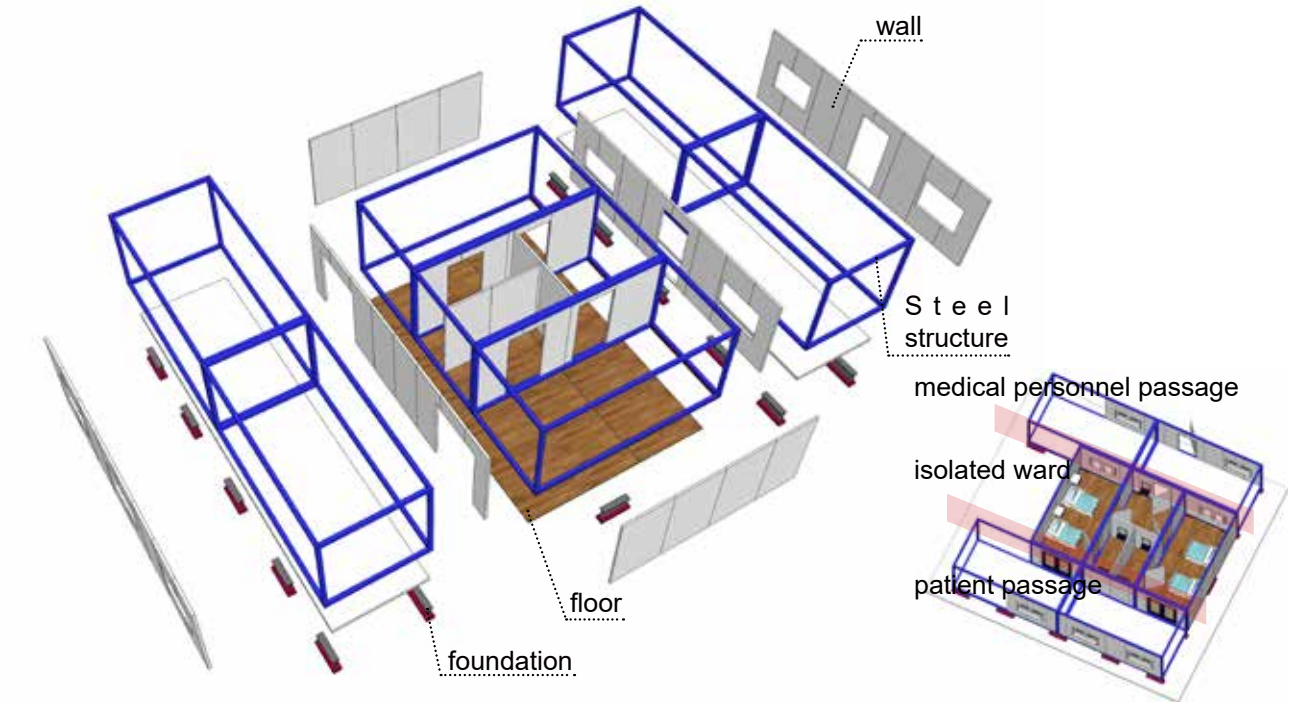


flow of medical working area

Medical personnel enter from the locker room, then go through the buffer zone, put on protective clothing in the designated room, and then enter the isolation area; when they come out of the isolation area, they will go to another designated room, take a shower, take off the protective clothing, and enter the buffer zone. At end go out from the locker room. The route is one-way.

Prefabricated steel structure

Leishenshan Hospital adopts a steel-structured box-type room for assembly-type installation and construction, with a high degree of industrialization / assembly and high speed.



The steel structure box house has outstanding advantages, which is very suitable as an emergency room in the field of temporary construction products or hospitals: [28]

1. easy transportation, prefabricated various components directly in the factory, and can be assembled directly on site;

2. durable and durable, Strong anti-seismic, anti-deformation and anti-deformation capabilities;

3. With heat insulation, moisture resistance, water lamp performance, and good sealing performance, strict manufacturing process makes it can be well used in infectious disease hospitals and other fields;

4. The movable room is based on the standard steel chassis, which can derive many combined spaces;

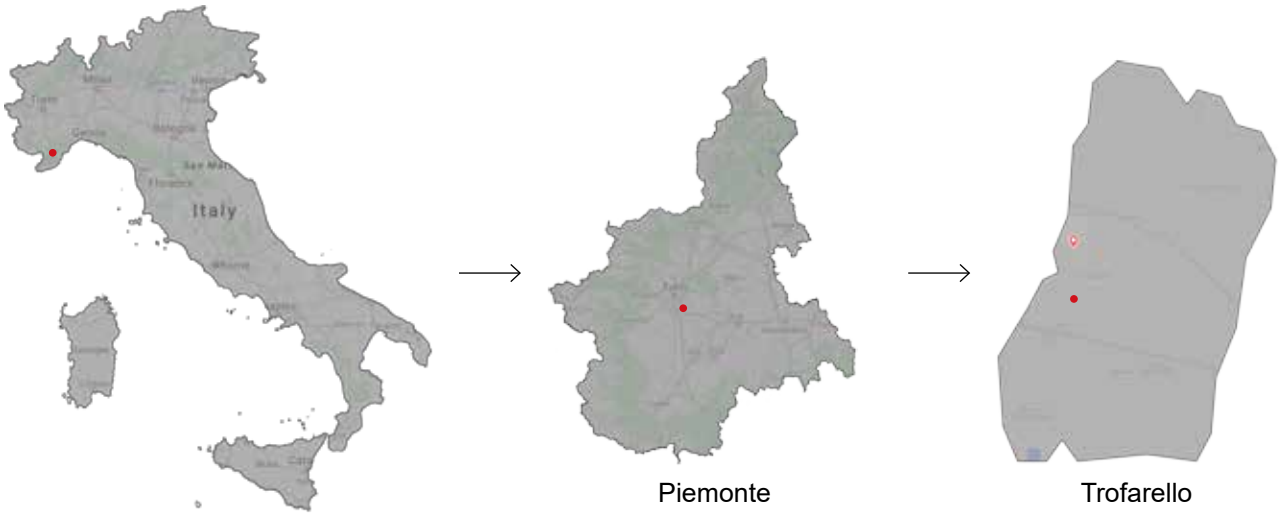
5. Flexible layout and convenient disassembly and assembly.

Chapter 3
The hospital project in Trofarello

3.1 Overview of Trofarello

3.1.1 Site analysis

The site we will design this time is located in Trofarello, in the province of Turin in the Piedmont region in northwestern Italy.



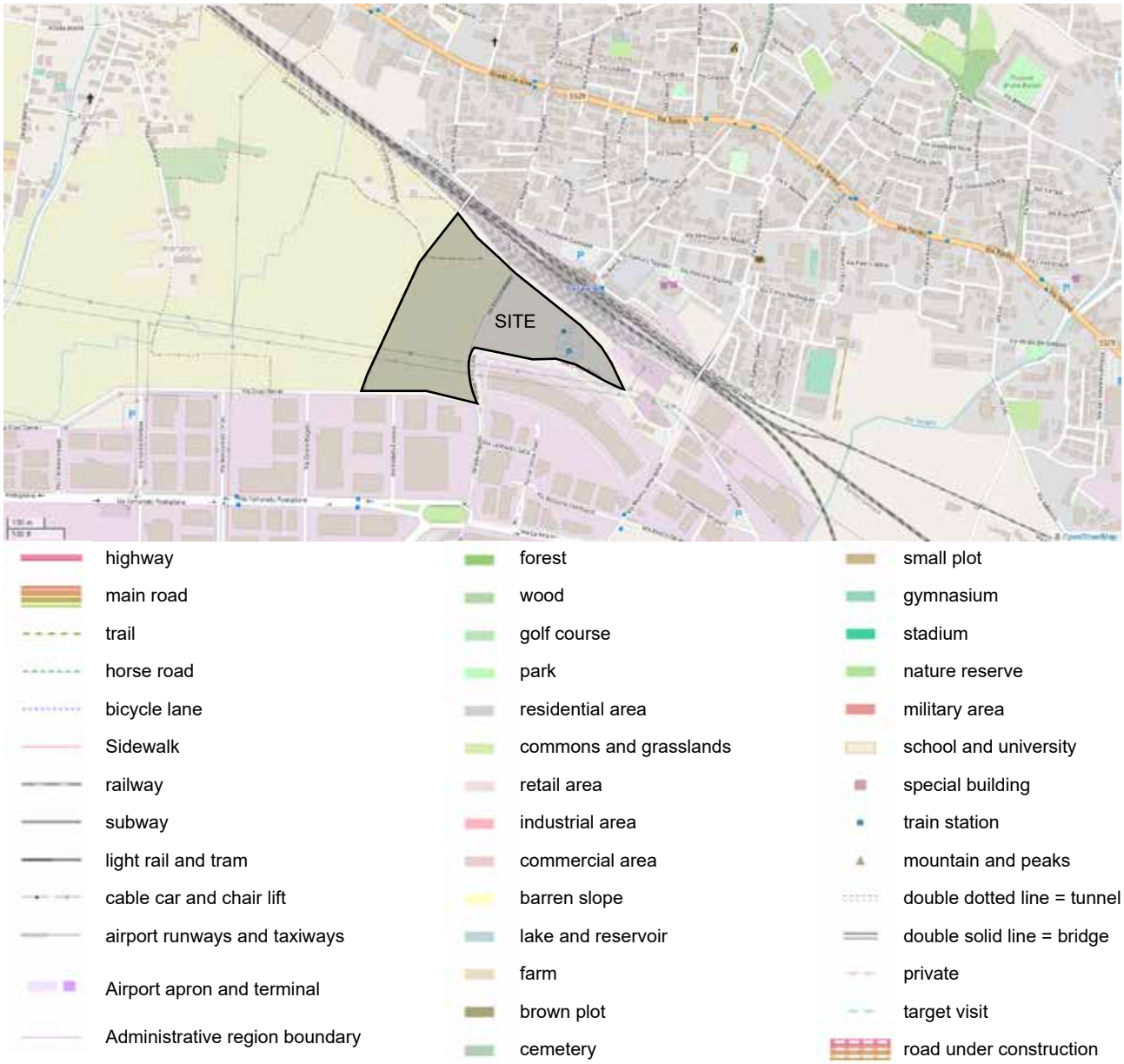
Italy Piemonte Trofarello

Hospital Site

3.1.2 Fuction and Traffic

The area of which the residential area of Trofarello is part is located on the marginal belt of the plain and on the first slopes of the Turin hilly system and, being part of Monferrato which has always been a transit place for communications along the plain and between the plain and hill, found itself inserted in the immense Roman road network. The routes from Piacenza to Tortona, Asti, Turin and Montgenèvre passed through it, leading to Gaul.

Our site is mainly urban to the northeast, industrial to the southeast, and farmland to the west.In the design, due to the unobstructed view to the west, we arranged the hospital part on the larger plot to the west, and the business district and hotel near the railway station to the east.



Functional analysis of the surrounding site[29]

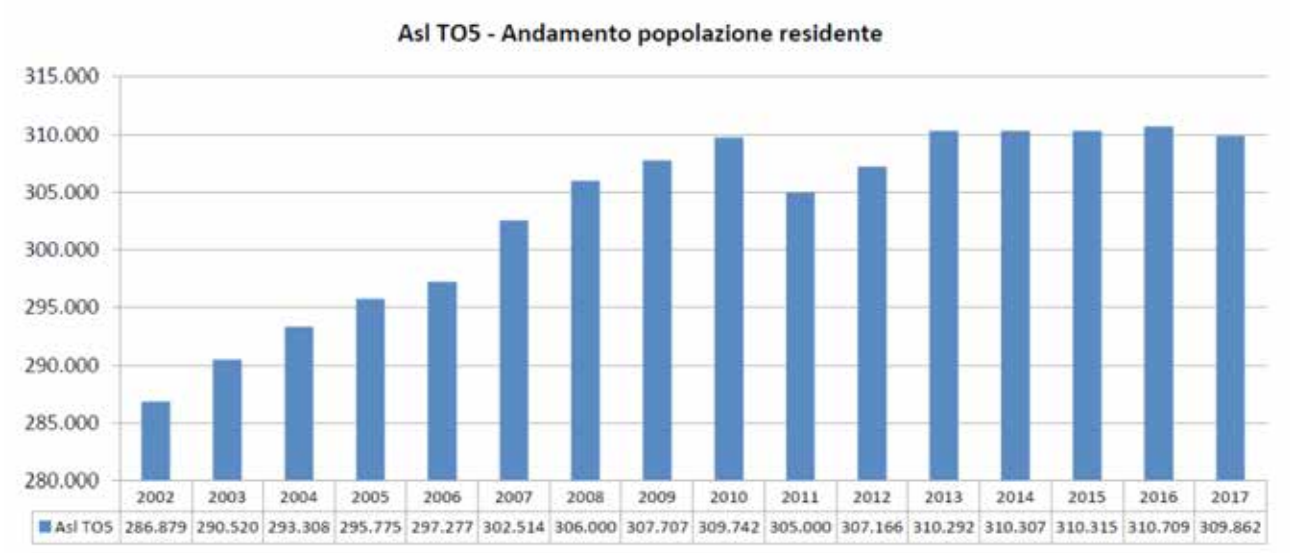
Trofarello traffic analysis

3.1.3 Population

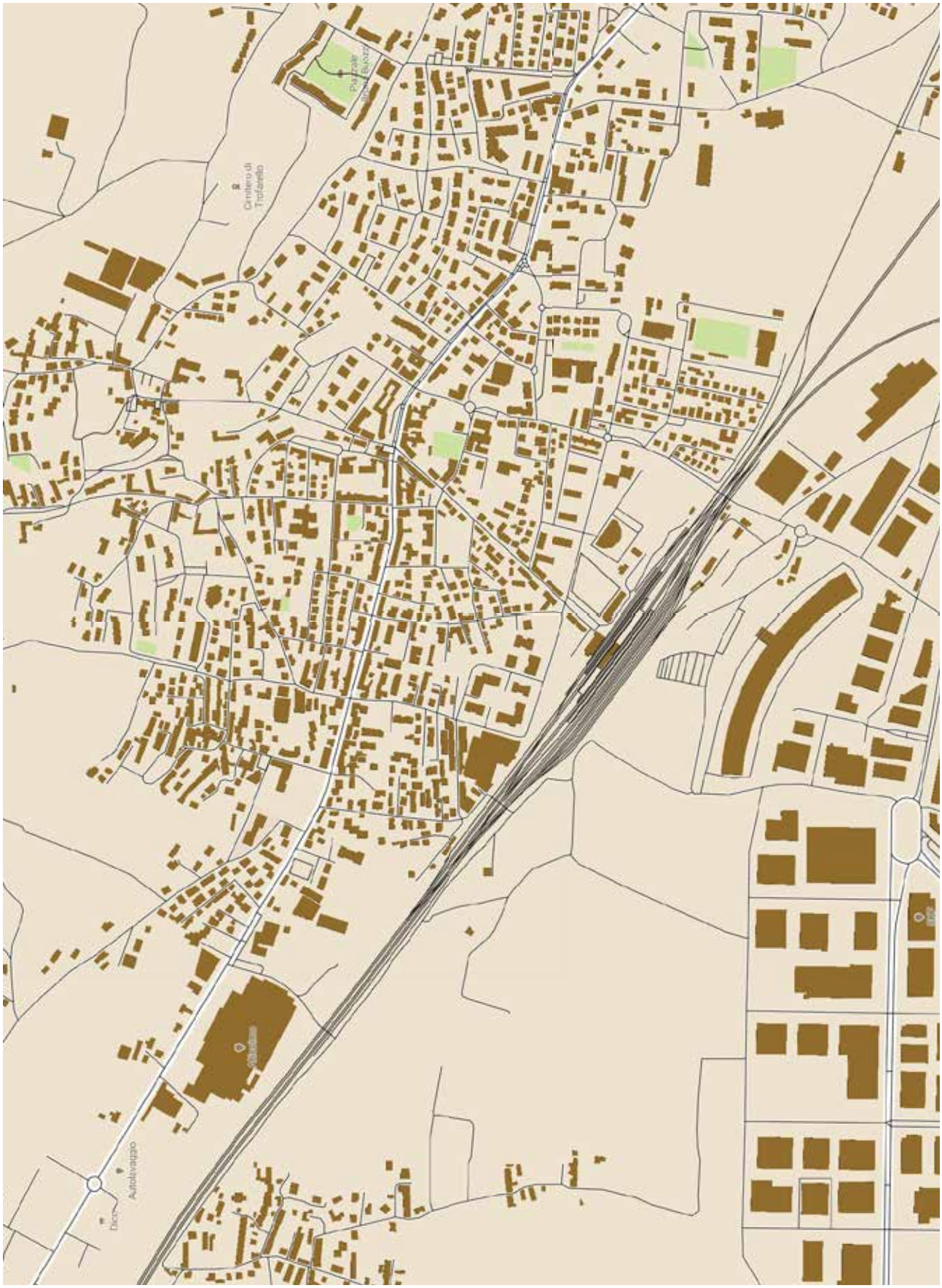
40 municipalities of the ASL TO5 divided by districts[30]

The ASL TO5 operates on a territory belonging to the province of Turin, with a total population of 309,862 inhabitants residing on 31 December 2017 *(Source: Piedmont Territorial Demographic Observatory)*, distributed in 40 municipalities, divided into 4 Chieri, Carmagnola, Moncalieri(include Trofarello) and Nichelino.

The population of the ASL TO5 shows a demographic trend that has steadily increased over the past 16 years (+ 0.50% annual average), as shown in the graph below *(Source: Piedmont Territorial Observatory)*:



3.1.4 Urban texture



3.1.5 Health statistics

ASL	Anno	Fino a 64 anni			65 anni e oltre		
		Dimissioni		Degenza media	Dimissioni		Degenza media
		Numero	Tasso grezzo per 100.000 residenti		Numero	Tasso grezzo per 100.000 residenti	
AL	2018	24,203	7,732.8	6.8	27,497	22,947.1	10.1
	2017	24,796	7,850.0	6.5	26,845	22,369.5	10.2
	2016	25,390	7,973.7	6.4	27,041	22,507.9	10.3
AT	2018	10,413	6,957.1	7.2	10,238	19,264.3	12.9
	2017	10,866	7,194.8	7.0	10,177	19,256.8	12.6
	2016	10,845	7,140.3	7.0	10,473	19,885.7	12.7
BI	2018	8,478	7,081.6	6.6	9,581	19,970.0	10.6
	2017	8,733	7,200.5	6.6	9,629	20,150.7	10.3
	2016	9,305	7,568.2	6.2	9,766	20,547.0	10.4
CN1	2018	22,887	7,266.8	7.1	22,609	22,372.7	11.5
	2017	23,215	7,327.5	6.8	22,409	22,305.1	11.6
	2016	23,784	7,473.3	6.9	22,551	22,616.1	11.7
CN2	2018	8,906	6,833.4	6.4	7,752	18,968.4	10.7
	2017	8,968	6,854.9	6.3	7,328	18,067.5	10.4
	2016	9,299	7,089.9	6.4	7,644	19,060.0	11.2
NO	2018	18,193	6,846.0	6.2	17,026	20,807.6	10.4
	2017	18,099	6,777.3	6.3	16,223	20,023.7	10.4
	2016	19,360	7,213.0	6.1	16,784	20,950.9	10.3
Torino	2018	42,813	6,585.8	7.8	45,447	20,143.2	13.9
	2017	43,818	6,670.9	7.7	45,653	20,229.6	13.7
	2016	44,870	6,791.8	7.9	47,460	20,982.5	13.5
TO3	2018	26,103	6,022.5	7.3	25,870	17,476.9	13.0
	2017	26,272	6,019.9	7.2	25,371	17,372.0	12.8
	2016	26,739	6,076.0	7.3	25,050	17,364.4	12.8
TO4	2018	24,974	6,466.5	7.3	24,698	19,263.1	13.3
	2017	25,056	6,436.8	7.2	24,665	19,421.9	13.3
	2016	25,662	6,540.6	7.0	25,034	19,905.7	13.2
TO5	2018	14,952	6,369.3	7.1	14,359	19,169.9	12.5
	2017	14,859	6,297.6	7.0	14,293	19,336.8	12.4
	2016	15,263	6,423.2	6.9	13,843	18,940.7	13.1
VC	2018	8,345	6,845.1	6.4	9,259	20,058.1	10.2
	2017	8,688	7,050.6	6.6	9,009	19,522.4	10.3
	2016	9,144	7,332.1	6.3	9,498	20,576.3	10.1
VCO	2018	8,375	6,756.2	6.4	9,072	20,144.8	11.2
	2017	8,829	7,050.1	6.5	9,364	20,999.8	11.1
	2016	9,614	7,631.2	6.2	9,245	20,847.0	11.6
Piemonte	2018	218,642	6,740.4	7.1	223,408	20,078.8	12.1
	2017	222,199	6,795.5	7.0	220,966	19,977.9	12.0
	2016	229,275	6,963.6	6.9	224,389	20,397.7	12.1

Fonte: elaborazione del Servizio sovrazonale di epidemiologia - Asl TO3 su dati del *Sistema informativo sanitario regionale*

Resignation and average hospitalization of ordinary hospitalizations
by Asl of residence - Years 2016-2018 [31]

For home care in Piedmont in 2017, the number of beds per 1,000 inhabitants was 79.4, which was 0.3 less than in 2016, second only to Trentino-Alto Adige, and ranked second in Italy. Semi-residential assistance is in the middle ranking, and there are relatively few beds for Residential assistance for rehabilitation. Finally, there are very few beds for Semi-residential assistance for rehabilitation.

Regione	Anno	Assistenza residenziale		Assistenza semiresidenziale		Assistenza residenziale per riabilitazione		Assistenza semiresidenziale per riabilitazione	
		Posti letto	Posti letto per 10.000 abitanti	Posti letto	Posti letto per 10.000 abitanti	Posti letto	Posti letto per 10.000 abitanti	Posti letto	Posti letto per 10.000 abitanti
Piemonte	2017	34,792	79.4	4,143	9.5	197	0.5	40	0.1
	2016	35,067	79.7	4,102	9.3	201	0.5	41	0.1
Valle d'Aosta	2017	167	13.2	31	2.5	0	0.0	0	0.0
	2016	157	12.4	32	2.6	0	0.0	0	0.0
Liguria	2017	8,068	51.7	1,083	6.9	1,200	7.7	998	6.4
	2016	8,031	51.2	1,098	7.0	1,237	7.9	1,029	6.6
Lombardia	2017	69,386	69.2	15,799	15.8	3,066	3.1	1,278	1.3
	2016	71,765	71.7	16,324	16.3	3,126	3.1	1,259	1.3
Trentino-Alto Adige	2017	8,826	82.9	603	5.7	62	0.6	8	0.1
	2016	9,743	91.8	510	4.8	184	1.7	13	0.1
Veneto	2017	36,765	74.9	9,802	20.0	165	0.3	508	1.0
	2016	36,750	74.8	10,333	21.0	180	0.4	523	1.1
Friuli-Venezia Giulia	2017	9,060	74.5	1,144	9.4	55	0.5	383	3.2
	2016	9,393	77.0	1,032	8.5	42	0.3	394	3.2
Emilia-Romagna	2017	21,656	48.7	8,802	19.8	253	0.6	15	0.0
	2016	22,025	49.5	9,006	20.2	257	0.6	15	0.0
Toscana	2017	13,711	36.7	3,813	10.2	1,174	3.1	1,020	2.7
	2016	14,055	37.5	3,968	10.6	1,210	3.2	1,079	2.9
Umbria	2017	3,201	36.1	1,365	15.4	173	2.0	166	1.9
	2016	3,363	37.8	1,457	16.4	171	1.9	184	2.1
Marche	2017	5,562	36.2	1,047	6.8	757	4.9	214	1.4
	2016	5,075	32.9	457	3.0	768	5.0	209	1.4
Lazio	2017	10,182	17.3	2,031	3.4	2,030	3.4	2,633	4.5
	2016	10,031	17.0	2,197	3.7	1,986	3.4	2,452	4.2
Abruzzo	2017	2,561	19.4	340	2.6	784	6.0	833	6.3
	2016	2,659	20.1	315	2.4	863	6.5	889	6.7
Molise	2017	196	6.4	55	1.8	199	6.4	76	2.4
	2016	208	6.7	55	1.8	198	6.4	72	2.3
Campania	2017	3,139	5.4	1,465	2.5	1,126	1.9	2,945	5.1
	2016	2,663	4.6	1,405	2.4	1,151	2.0	3,136	5.4
Puglia	2017	8,111	20.0	3,468	8.6	1,156	2.9	671	1.7
	2016	8,230	20.2	2,774	6.8	1,141	2.8	830	2.0
Basilicata	2017	553	9.7	76	1.3	454	8.0	175	3.1
	2016	537	9.4	62	1.1	462	8.1	186	3.3
Calabria	2017	3,697	18.9	201	1.0	521	2.7	249	1.3
	2016	3,724	18.9	298	1.5	493	2.5	264	1.3
Sicilia	2017	3,909	7.8	949	1.9	776	1.5	1,637	3.3
	2016	2,037	4.0	520	1.0	758	1.5	1,686	3.3
Sardegna	2017	1,941	11.8	550	3.3	654	4.0	874	5.3
	2016	4,063	24.5	773	4.7	640	3.9	1,045	6.3
Italia	2017	245,482	40.6	56,766	9.4	14,806	2.5	14,723	2.4
	2016	249,587	41.2	56,729	9.4	15,075	2.5	15,318	2.5

Fonte: Ministero della Salute

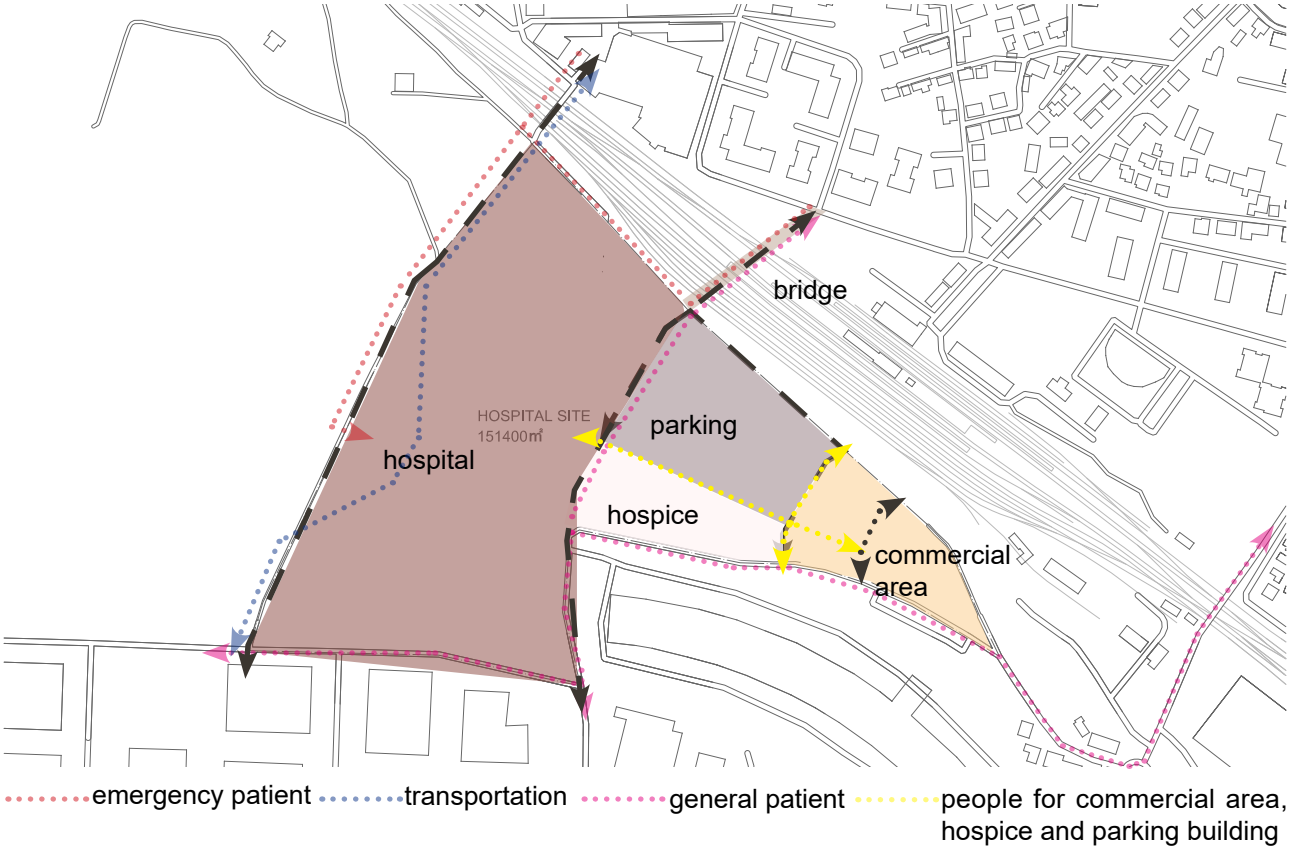
Residential and semi-residential care beds due to the presence of rehabilitation and the region Years 2016-2017 [31]

ASL	Anno	Varicella	Scarlattina	Salmonellosi non tifoidea	Blenorragia	Sifilide	Legionellosi	Malaria	Meningo-encefalite	Tubercolosi
AL	2018	215	29	36	0	16	16	3	4	32
	2017	416	68	42	0	6	12	7	10	44
	2016	367	64	63	2	2	8	3	3	48
AT	2018	295	166	23	0	0	7	1	0	16
	2017	104	28	27	2	1	3	2	1	11
	2016	322	93	28	1	1	4	2	0	7
BI	2018	263	38	5	1	0	2	0	0	8
	2017	209	62	22	0	2	1	1	0	3
	2016	228	126	8	0	0	1	1	0	3
CN1	2018	1,103	146	24	2	1	35	13	13	36
	2017	1,575	193	40	2	2	5	21	4	39
	2016	1,228	263	23	0	1	5	22	6	33
CN2	2018	584	143	44	1	3	15	3	2	16
	2017	1,004	82	40	2	1	5	3	5	12
	2016	925	80	32	1	0	10	3	2	8
NO	2018	293	16	18	1	0	6	15	7	28
	2017	147	18	31	0	1	20	5	2	25
	2016	272	9	26	0	1	6	11	2	24
Torino	2018	2,912	85	26	242	141	42	32	19	121
	2017	728	52	24	194	131	25	32	20	104
	2016	357	71	9	192	150	36	31	27	133
TO3	2018	988	35	39	9	2	22	5	5	30
	2017	545	19	39	5	5	14	5	11	24
	2016	558	42	32	12	7	15	3	17	30
TO4	2018	471	8	5	4	3	7	7	7	35
	2017	321	12	17	6	9	5	8	9	40
	2016	249	16	19	6	7	10	7	12	36
TO5	2018	1,043	67	32	5	6	11	1	4	16
	2017	150	49	18	5	2	9	6	6	23
	2016	244	29	26	4	2	5	1	11	25
VC	2018	93	17	13	0	0	10	0	3	6
	2017	60	16	8	0	0	2	0	1	16
	2016	50	7	11	0	0	1	3	0	6
VCO	2018	159	36	28	0	1	2	3	5	9
	2017	382	73	18	0	0	8	3	2	10
	2016	186	47	13	0	1	12	0	1	11
Piemonte	2018	8,419	786	293	265	173	175	83	69	353
	2017	5,641	672	326	216	160	109	93	71	351
	2016	4,986	847	290	218	172	113	87	81	364

Reported cases of infectious diseases by Asl of residence - Years 2016-2018[31]

The most common case of infectious diseases in 2016-2018 was chickenpox, and these three years showed an upward trend, with the largest number of cases in 2018. Followed by scarlet fever, the least is meningoencephalitis. It is believed that the most infectious disease case in 2020 is COVID-19.

3.2 Design ideas of hospital



Accessibility : The site is located in the south of Trofarello railway station, close to the railway. To the north of the railway station is the city center of Trofarello. However, there are few roads to cross the railway from north to south, and there is only one bridge near the hospital.Therefore, we decided to build the main road of the hospital in the center of the site, and connect it to the northern city through the railway line, and connect the existing roads in the city with the circular road, so that the residents of Trofarello could get to the hospital more easily.At the same time, considering the patients who come to the hospital by train, we have opened another north-south road in the site, which can directly lead to the underground of the railway station, so that those who take the train can go to the hospital directly from the railway station.The road at the westernmost end of the site is planned as an emergency and transport corridor, allowing only ambulances and staff to pass.

Through the geographical location of the road, we set up seven entrances: four open entrances and three for emergency patients and staff only.The three staff entrances are on the west side of the hospital (rear facade), one main entrance, two entrances leading to the city and the railway station, and one parking entrance leading to the parking building and the business district.

Functional zoning: Due to the irregular shape of the site, the west is approximately rectangular and the east is approximately triangular.The site is divided into three parts according to three north-south roads: the main part of the hospital, Hospice, the parking building and the business district.We placed the most important hospital body in a more spacious area to the west;A parking lot is placed in the middle, which is convenient for people to park in both east and west directions. Hospice is arranged in the south of the

parking building.The east side has a shopping center.

People flow line: According to the different people coming to the hospital, we divided people flow line according to the road, mainly distinguishing the flow line of ordinary patients, emergency patients, staff and commercial personnel.

3.2.1 The overall layout of modularity

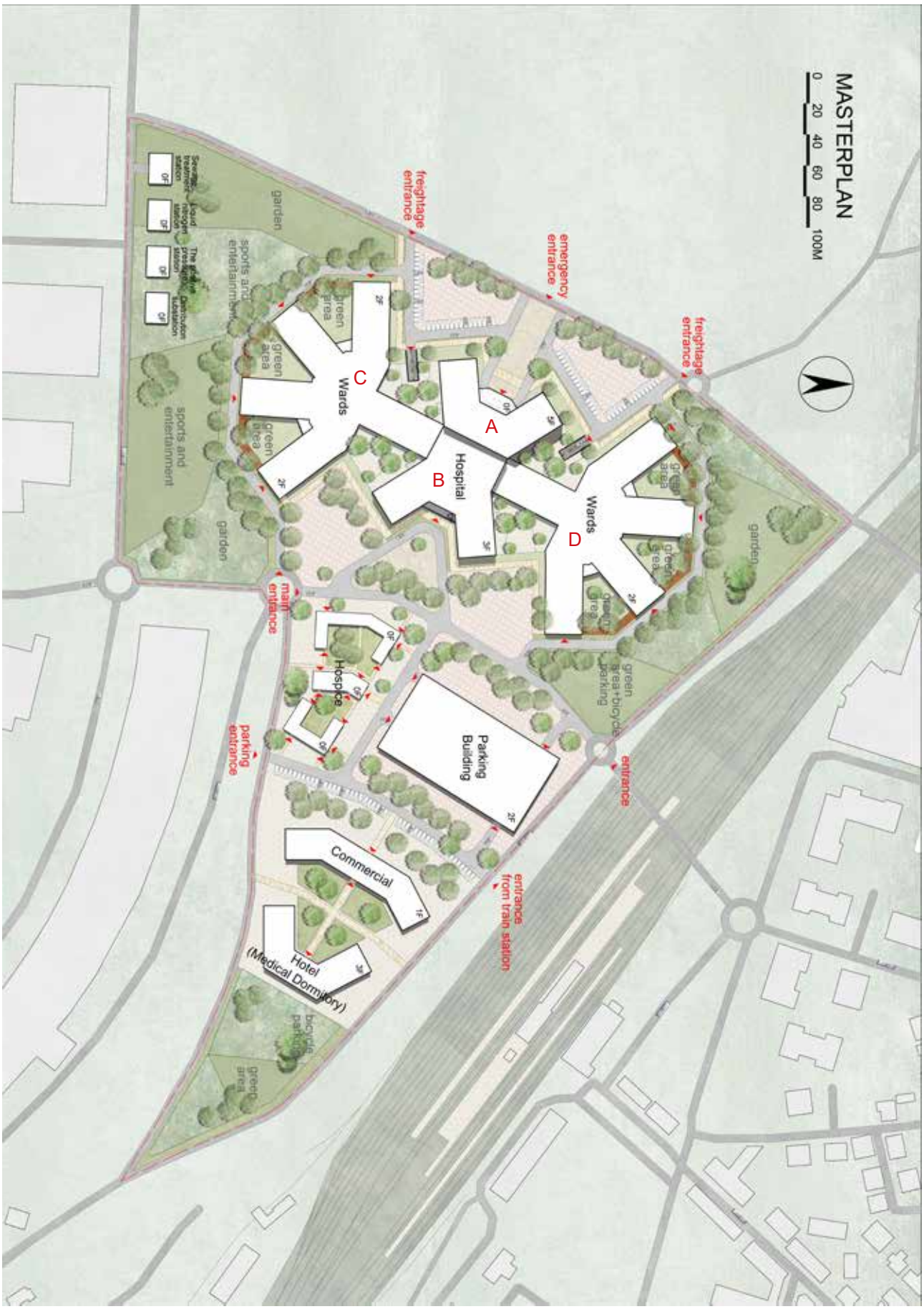
In the hospital building design, we take the whole hospital as a system according to the classification theory of medical building system, and divide it into outpatient(emergency) department module, medical technology module, inpatient module and auxiliary module according to the function.Through the hospital four part(A,B,C,D) organic combination of each functional module, a complete hospital function is formed. Among them, each medical unit module adopts unified structure, technical parameters and construction method, combined with "medical street", which effectively enhances the mobility of each part of the building space.

The hospital site is 277.2 meters long from north to south and 137.9 meters long from east to west, with the medical technology area in the middle and the inpatient area from north to south.The overall planning of the project combines the concept of modular design, fully considers the scientific and reasonable processing process and improves service efficiency, and connects all modules with the north-south corridor of the central axis. The core of the hospital medical area is mainly composed of outpatient, emergency, inpatient and medical modules. The emergency module and medical module are arranged in the central area, and some medical modules, outpatient module and inpatient module are located in the north and south ends. In this way, medical resources of the center can be conveniently Shared.

The public property of the hospital determines that the external space function of the building should be directly connected with the urban road space to realize the distribution of adult flow. Located at the southern end of Trofarello, the hospital is easily accessible with a commercial area, car park and Hospice, also have the green square and fitness area. The main road in front of the hospital serves as an organic interface between the hospital and the city and the train station. Rhythmically modularized layout of outpatient and emergency department, medical modules and inpatient department forms a interesting courtyard space, which solves the needs of ventilation and lighting in the hospital and creates a more comfortable medical environment for patients and medical staff.

The overall layout of the external flow lines of the modular building is clear. In various external flow lines, we separate the reasonable flow lines of transportation, staff, ordinary patients and emergency patients, so that there is no crossover, no interference and each goes its own way.

In the site we designed three parts according to the two streets which through south and north of the site: one is hospital base, one is parking building and hospice, another one is commercial area.



Masterplan of Hospital

3.2.2 Functional space organization of modules

The organization and requirements for all the hospital spaces have been from Hare Programe of the Piedmont Region healthcare authority DGRI.The figures are requested in the following table:

	Reception Area	**Inpatient department**
Area(㎡)	1000 (960)	20700 (20748)
Area(㎡)	**Outpatient and Emergency Department** 16400 (2873+1078+2300+978+9239=16378) pharmacy(1605) The Morgue &Monitoring center(1313) Diagnosis area(2458) Day surgery operating rooms(3863)	**01-Medical area 167（number of beds)** Cardiology 12 General Medicine and Neurology127 Emergency Medicine 14 Day Hospital-Day Service 14 (3 Cardiology + 10 General Medicine + Neurology)
Area(㎡)	**Primary Connective, Central and Technological Sub-plants** 14300(2946+1878+10318=14692) Pathology department (3576) clinical lab(2458) Radiology and diagnostic imaging/intervention (2458) Pharmacy/Blood Bank(1826)	**02-Operating area 145** General hospitalization (gynecology, urology, otolaryngology) 77 Orthopaedics and Traumatology General Hospitalization 40 Day surgery 28 (18 general surgery + 4 ENT + 2 urology + 4 orthopedics and traumatology)
Area(㎡)	**Logistic Support Services Area** 6100(2458+1672+4287=8417) Public Service Central sterilization Room service Personal dressing room Laundry / cloakroom Medical Lounge	**03 Newborn area of obstetrics 62** Obstetric Hospitalization 26+1 Pediatric hospitalization 14+3 Newborn hospitalization 14 Neonatal Intensive Treatment 4 Delivery block (4 delivery rooms + obstetric operating room) Baby room (25 cots) **04 Emergency area 15** Intensive Care Unit 9 Coronary artery 6

In the hospital design, we specifically divide the whole medical area into outpatient area, emergency area, medical technology area, inpatient area, administration and managerial area, etc., as well as logistics support area, including reception area, service area and connection area. As you can see on the table above, the black color numbers are the area of each department required, and red numbers are the actual area of each department.

The Outpatient and Emergency areas covered 16,378 square meters. They are divided into Emergency areas, Monitoring Center, Morgue&Monitoring Center, Diagnosis area and Day surgery Operating rooms.

The outpatient area is located in the second floor of the C,D area in the north and south of the site. The entrance is wide and bright, combined with a spacious corridor, providing comfortable and spacious separation and waiting space for patients and medical staff. Daylighting landscape is designed in C,D part, from groundfloor to tallest floor, also through outpatient department, which broadens people's vision and makes people feel comfortable. According to the scale of the hospital construction, two outpatient modules are set up, which are connected in series on the principal axis, and the modules were connected to each other through the corridor.

The emergency area is adjacent to the west road and has independent entrances and exits with independent passageways.The emergency module has clear emergency and first-aid division, and the road leading to emergency is separated from the flow line of ordinary patients, which is efficient and convenient.

The total area of the medical technology area and the connected area is 14,692 square meters, of which the Pathology Department, Radiology and Diagnostic imaging/ intervention, Clinical lab, Radiology and Diagnostic imaging/intervention, Pharmacy/Blood Bank are set.

Inpatient department total area of 20,748 square meters, is divided into medical area, operating area, newborn area of obstetrics, emergency area, informed area and post - acute area such as outpatient wards.The hospital module plan adopts the form of double corridor layout, and the spacious activity space and comfortable room layout reflect the basic concept of humanized design. Different outpatient wards have different beds, and some outpatient wards have different functional arrangements. For example, there are delivery room, obstetric operating room and baby room in the gynecological area. Considering the situation of patients needs to be intensified care, ICU is closed to general people, allowing only medical staff and family members that come to visit to enter. CCU equipped with all single rooms, the rooms are very comfortable, spacious and bright. Spacious activity areas and comfortable room layout reflects the basic concept of humanized design.

The following table is the data about area index of different fuctions of our actual design:

Functions	Areas（㎡）
HOSPITAL BUILDING	93881.23
HOSPITAL_-1F	23967.56
Radiology department	1230.68
Morgue	971.89
Monitoring center	971.89
Equipment rooms	2082.38
Warehouses	5039.52
Kitchen	429.66
Other traffic spaces and toliets	13241.54
HOSPITAL_0F	18707.94
Emergency area	1429.30
Embulance entrance area	227.95
Blood bank	538.80
Pharmacy area	538.80
Enteric outpatient area	284.86
Hepatitis outpatient area	284.86
Pediatric outpatient area	284.86
Canteen	319.04
Wards	4627.04
Other traffic spaces and toliets	10172.43
HOSPITAL_1F	20299.61
Consulting area	2127.84
Emergency ICU	616.53
Computer center	1323.79
Day surgery operating rooms(7)	1165.24
Wards	4627.04
Other traffic spaces and toliets	10439.17
HOSPITAL_2F	19776.64
Surgery operating rooms（8）	2328.60
Dialysis area	2042.54
ICU 11 beds	502.70
CCU 6 beds（ICU for heart desease）	566.85
Wards	4627.04
Other traffic spaces and toliets	9708.91
HOSPITAL_3F	6112.56
Clinical lab	1655.70
Pathology department	2114.47
Other traffic spaces and toliets	2342.39
HOSPITAL_4F	2508.46
Staff canteen	1464.32
Lecture hall	599.93
Other traffic spaces and toliets	444.21
HOSPITAL_5F	2508.46
Administrative office	761.51
Library and archives	807.44
Other traffic spaces and toliets	939.51

Functions	Areas（㎡）
HOSPICE	1704.78
HOSPICE EAST_0F	743.50
Hospice wards	382.61
Service stations and equipment rooms	136.47
Other traffic spaces and toliets	224.42
HOSPICE MID_0F	426.80
Reception and offices	130.01
Restaurant and kitchen	151.51
Other traffic spaces and toliets	145.28
HOSPICE WEST_0F	534.48
Hospice wards	281.27
Service stations and equipment rooms	101.76
Other traffic spaces and toliets	151.45
COMMERCIAL	4084.38
COMMERCIAL_0F	1907.68
Shops	1025.02
Warehouses	248.80
Other traffic spaces and toliets	633.86
COMMERCIAL_1F	2176.70
Shops	1114.08
Warehouses	248.80
Other traffic spaces and toliets	813.82
HOTEL	6424.52
HOTEL_0F	2176.70
Reception area	467.62
Multifunctional media hal	334.56
Fitness room	136.27
Meeting rooms	193.32
Restaurant and kitchen	376.07
Other traffic spaces and toliets	668.86
HOTEL_1F/2F	2176.70
Hotel rooms	1218.59
Fitness room	136.27
Warehouses	67.00
Other traffic spaces and toliets	754.84
HOTEL_3F	2071.12
Multifunctional media hal	167.28
Suite	604.34
garden	211.16
Offices and warehouses	628.32
Other traffic spaces and toliets	460.02
PARKING BUILDING	17664.48
Parking area and roadway (for 3 Floors)	17230.98
Stairs, elevators and toliets (for 3 Floors)	433.50
TECHNOLOGY BUILDING	1200.00
Sewage treatment station	300.00
Liquid nitrogen station	300.00
The positive pressure station	300.00
Distribution substation	300.00

3.3 Standardization of basic unit modules

General hospitals are located in more populated areas of the country.When the fund falls into the shortage of construction resources, and is subject to the non-standard unit module, the modular hospital always chooses the site and the environment is unqualified.Therefore, using the existing elastic principle of medical design, the modular design of the target object is more universal, more stable, smaller target unit is in line with the current situation. In this way, it not only benefits the flexibility and ductility of modular design, but also brings more practical benefits to scientific exploration.

"Unit module" is the foundation of modular hospital construction. In the system, unit module is often repeated and indispensable, which remains unchanged in the process of system combination.The most basic unit modules utilize the shape and size of standard modules in the design of modular hospitals to reduce the duplication of design effort in order to be able to utilize modular modules, thus reducing and consolidating specialized departments, while the use of modular modules also facilitates the reduction of building pointing and design and construction cycles.

The outpatient clinic, imaging room, operating room and nursing ward are functionally related to the outpatient department, medical technology department and inpatient department of general hospital;It is also the most frequently used module unit in doctor-patient activities, with the most retention time, and the highest frequency and repeatability in medical functions, with a very distinct representativeness.

3.4 Analysis of the characteristics of architectural elements of modules in clean surgical department

-A systematic overview of clean surgical department and its influencing factors
In general, the cleanroom building system covers equipment, medical procedures, layout, sizing, area allocation, and room composition.

Based on the study of several large hospital buildings in China, we propose the following six factors for the construction system of clean surgery department:
1. Occupancy relationship of equipment and equipment in the clean operation department
2. Clean the medical procedures of the surgical department
3. Clean the plane position and layout of the operation department
4. Determination of the number and scale of operations in the clean operation department
5. The area distribution ratio of each part of the clean operation department
6. The rooms in the clean Surgery Department constitute the clean grade

As the architectural system of the clean surgery department, its design factors are mainly influenced by the management system of the clean surgery Department. Due to the existence of the management system of the clean surgery Department, it will have a guiding influence on the architectural design of the clean surgery Department, and other systems of the clean surgery Department will also be changed due to its changes. Clean operating department building system of some factors, such as: medical process in the department of surgery, the plane position and the plane layout, clean level, the area ratio of each part, the way of the combination of the basic functional unit stitching is the management of the clean operating department system or the management of the clean operating department working principle should be each other.In addition, in the clean operating department has also been in the clean operating department information system, the effect of medical equipment and equipment system, this is mainly embodied in the medical science and technology research and development and technological progress, a large number of medical equipment and upgrading of information system of clean operating department, and puts forward new requirements to the construction of the clean operating department, in order to save precious health resources, modern large-scale comprehensive hospitals are put forward the construction of network information sharing and long-distance expert consultation and so on, relying on the Internet platform of information system, and to carry out the construction of the clean operating department in online long-distance expert guidance and other experts in the operation such as online operation,A variety of surgical methods and methods.In this process, the size and size of the main instruments and equipment used also have an impact on the operating room scale of the clean operation department.In short, with the rapid development of medical technology, the main factors affecting the department of clean surgery will become more and more complex.

-Classification of functional rooms in surgical department
The modern Department of Clean Surgery is mainly composed of several functional areas. Its main areas include the core area of surgery, the health pass area, the central supply area, the other medical area and the teaching room area.The core area of the operation and the clean corridor are composed of a number of clean operating rooms, the sanitary corridor constitutes the main part of the clean operating department through the area, the central supply area and other medical areas, and the teaching room area forms the ancillary room part.Modern clean operation department system is numerous, and the

medical equipment is confidential and complex, corresponding clean operation department function room is also more, according to different hospital building layout and management system, the composition of the operation department is slightly different. But the basic components are as follows:
1. Sanitary passage area: clean passage, polluted passage and space of bed-changing hall.
2. Operation core area: including operating rooms of various levels.
3. Center supply area: the main task is to directly provide services for different levels of clean operating rooms.Such as brush room, pre-hemp room, recovery room, sterile storage room, preparation room, etc.
4. Other medical areas: medical office, duty room, anaesthesia office, gypsum room, waiting area for family members, sewage storage area, purification air conditioning equipment, medical gas and distribution room, etc.
5. Teaching room area: it is mainly composed of classroom, teaching observation room, conference room and other teaching rooms.

The first three functional areas: health pass area, surgical core area, and central supply area are the most core and essential areas in the department of clean surgery.The latter two functional areas can be arranged according to the actual situation of the hospital itself. For example, the endoscopy room and frozen section room in other medical areas can be located in the medical technology section, and some equipment rooms in the operating room can also be designed outside the operating room according to the conditions.

3.4.1 Operation department module room composition and cleanliness level

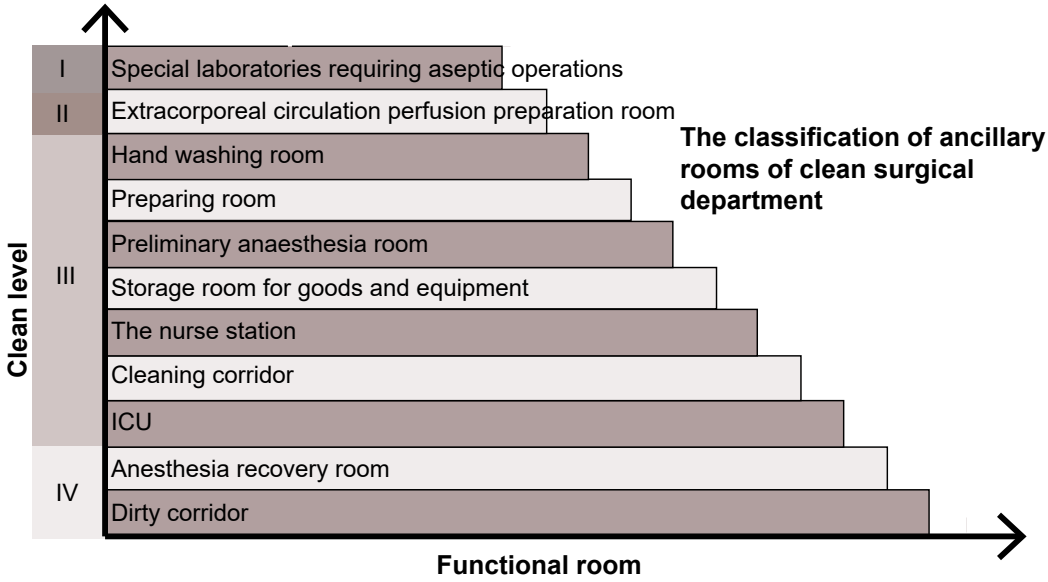
The current composition of each functional room of the clean operation department is gradually formed with the development of the operation department, and the cleanliness level is managed according to the different operation tasks of the clean operation room.

According to the above mentioned, the modern clean surgery department is mainly composed of several functional areas. The main areas include the surgical core area, the health pass area, the central supply area, the other medical area and the teaching room area.The core area of the operation and the clean corridor are composed of a number of clean operating rooms, the sanitary corridor constitutes the main part of the clean operating department through the area, the central supply area and other medical areas, and the teaching room area forms the ancillary room part.

There are many functional rooms in the clean operation department, and there are different requirements for the cleanliness level in the room.The cleanness grade of functional rooms in the clean operation department is mainly divided from two parts: the clean operating room and the auxiliary room of the clean operation department.The reason is to use different cleanliness according to different cleaning needs, in order to reduce the cost of construction.“The cleanliness in so - called indoor room is to point to the effective control of life particles and dust particles to achieve. Specific measurements are made by measuring the concentration of bacteria and dust particles in a given space.”[32]Through the above methods and the actual needs of the room, we will clean the operating room according to the type of surgery it undertakes and the situation of the trauma surface generated by the operation.Hospitals and medicine generally divide clean operating rooms into four categories:
Category I: Special clean operating room: joint replacement surgery, organ transplantation

surgery, brain surgery, heart surgery, ophthalmology and other operations in the sterile operation;
Class II: Standard clean operating room: brain surgery, plastic surgery, urology, hepatobiliary surgery, bone surgery and general surgery in the first class of incision sterile surgery;
Class III: general clean operating room: general surgery (except for the first type of surgery), obstetrics and gynecology and other operations;
Class IV: quasi - clean operating room: anorectal surgery and contamination operations.

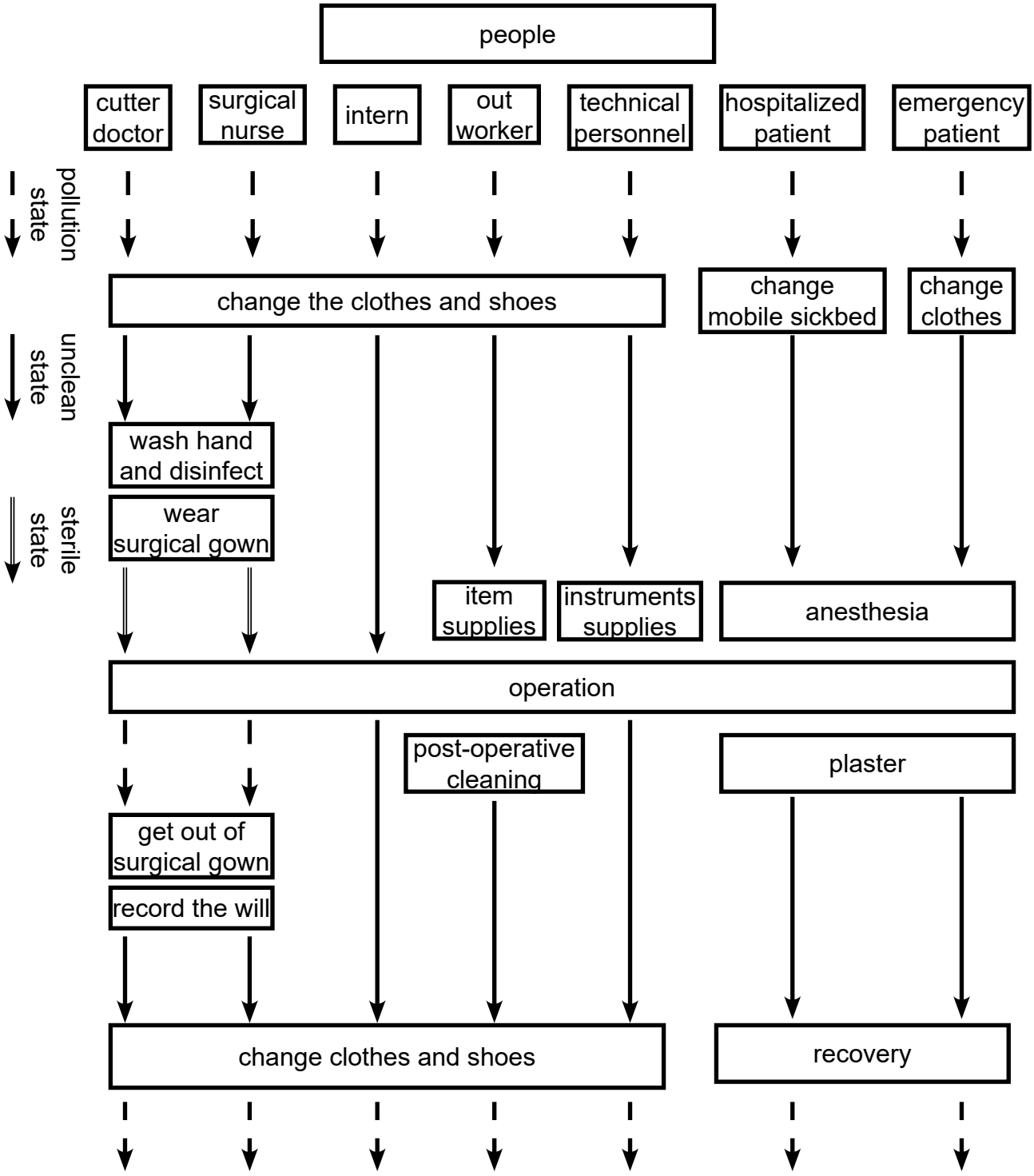
For the division of the cleanliness grade of the auxiliary room of the clean operation department, the requirements of the clean area in which they are located and the requirements of the cleanliness degree of the medical activities in the room are mainly considered. Within the scope of the clean operation department studied in this paper, auxiliary rooms are located in the sanitation pass area and the central supply area, and the cleanliness level required is mostly level 3. Moreover, the classification of cleanliness level in the auxiliary rooms of the clean operation department is conducive to the daily management and infection control requirements of the operation department. The classification of auxiliary cleaning rooms is shown in the figure.



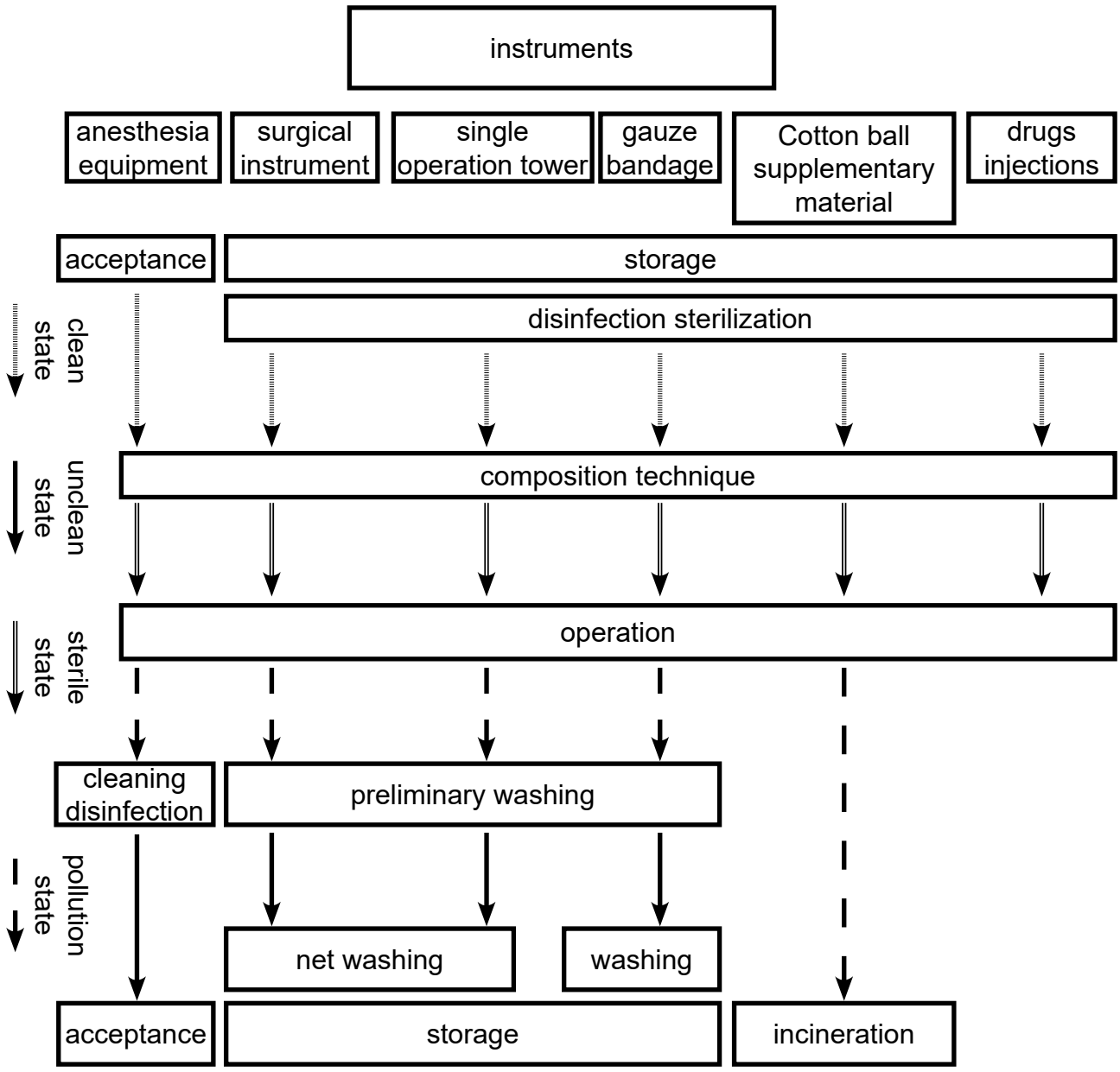
classification of auxiliary cleaning rooms

3.4.2 Medical flow line in the clean surgical department

There are two main flow lines in the clean operation department: personnel flow line and equipment flow line through the clean operation department.The influence of the medical streamline on the plane layout of the clean operation department should be considered in addition to the decontamination area.In the personnel flow line, it mainly includes the surgeon and the surgical patients.In the sewage flow line, it mainly includes articles such as medical devices, medicines, blood and dirt.The analysis of the medical flow line of the clean operation department plays a key role in the architectural design of the whole clean operation department.



people streamline

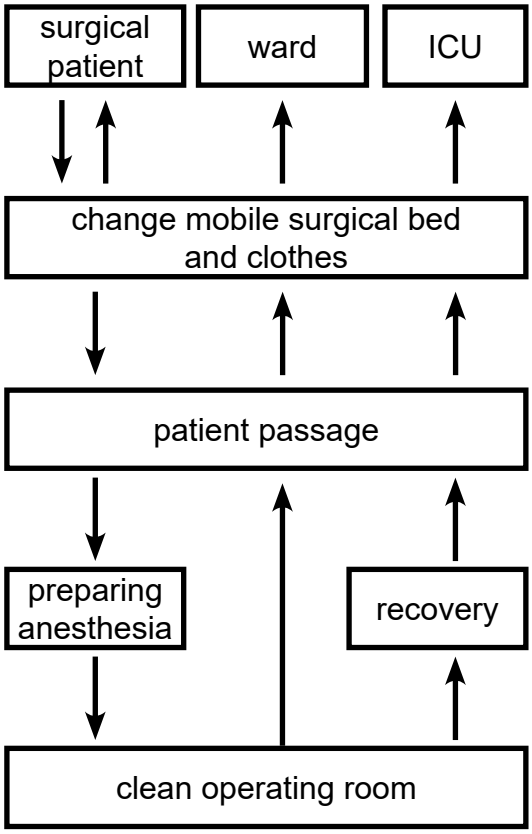


medical instruments and meterials streamline

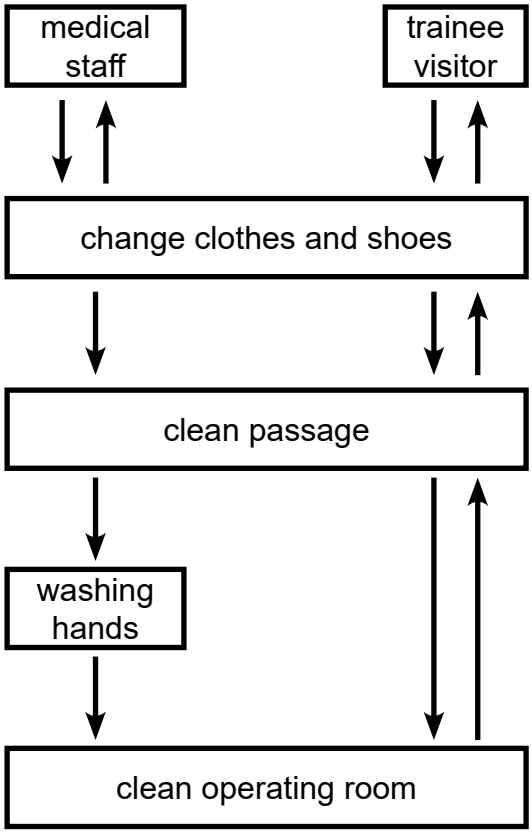
As medical personnel, cleaning and dirt all have busy medical activities in the department of clean surgery in large general hospitals, the streamline relationship of the department of clean surgery is complex. In order to clearly and clearly reflect the streamline relationship in the department of clean surgery, we draw a streamline relationship diagram of its streamline relationship, as shown in the above details.In the figure, we can clearly see the degree of cleanliness between each streamline in the cleaning operation department, and distinguish clean and contaminated areas from the figure to prevent cross infection.

In the streamline of people flow, it mainly includes the surgeon and the surgical patient:
The surgeon, assist doctors and nurses from replacement slippers, disinfection, washing bath change clothes after the replacement surgery clothes, masks, and finally by the secondary change of shoes before entering into the clean operating department, brush in hand disinfection, enter the clean operating room, in which implements the operation activities, after the surgery, the doctor left clean operating room, record orders and families to talk, leave the clean operating department, took off his clothing and shoes, in disinfection wash bath, change clothes, eventually leave.

Surgical patients: the streamline procedure of medical staff is much simpler. First, it is the preparation before the operation, including bathing, skin preparation and disinfection before the operation, changing the operating clothes and sending them to the clean operation department. After entering and leaving the operation department, the patient will change the bed, change the push bed in the clean operation department, and push the bed to the anesthesia room and operation preparation room, and then enter the clean operation room. When the operation is over, the patient will wake up in the recovery room or restore the room, and finally leave the operating room and return to the ward or ICU



procedure of surgical patients



procedure of medical staff

The flow of items from the department is mainly through the supply of sterile instruments and medicines into the flow line and from the post-operative contamination of medical waste and sewage equipment out of the department. The two streamlines are required to be separated in principle. The supplies include: drugs, narcotics, blood and pathological specimens. Postoperative contaminated items mainly include postoperative instruments, excipients and postoperative surgical waste.

Supplies from the clean operation department enter the clean operating room from their respective storeroom through the special building elevator or the clean goods elevator in the operating room through the clean corridor. Postoperative contaminated items mainly include postoperative instruments, auxiliary materials and medical waste, which leave the clean operation department through the sewage corridor through the separation, packaging and cleaning processes, and are sent to the sewage room, and then sent to the disinfection room and the incinerator respectively through the special elevator.

Through the above analysis, we know that the main groups of people who use clean operating room mainly include patients, surgeon, nurse, auxiliary doctors and equipment

and accessories in clean operating room. Finally, the flow line of medical behavior in and out of the clean operating room can be roughly divided into the following 6 types: (1) Preoperative patients, (2) Postoperative patients, (3) Preoperative staff, (4) Postoperative staff, (5)Sterile equipment, (6) Contaminated equipment. Under ideal circumstances, each of the six streamlines must be strictly separated before entering or leaving the clean operating room. However, in the actual situation, some of these streamlines will be combined into one in order to consider the economic needs.

-Clean-dirty partition

In the plane layout of the clean operation department, all rooms should be divided according to their cleanliness.Clean operation department can be generally divided into the following areas: ultra-clean area, purification area, aseptic area, clean area, non-clean area and so on.

The basis of the plane layout of the clean operation department is made according to the room composition and infection control requirements of the clean operation department. Due to the different connections and cleanliness of each functional room, these rooms must be combined and divided according to certain rules between rooms, so as to form a reasonable and economic clean operation department.

3.4.3 Basic equipment of the clean operating room

In China, there are clear requirements for basic equipment of clean operating room.

instrument name	Minimum configuration quantity(each room)
Astral lamp	1
Operating table	1
The timer	1
Medical air source device	2
Anaesthetic gas discharge device	1
Hands-free intercom	1
viewing lamp	3(small) 4(middle) 5(large)
Clean, disinfect and sterilize the unit	1(each 2 rooms)
Drug cabinet	1
Instrument cabinet	1
Anesthesia cabinet	1
4 infusion guide rails or hooks	1
Record board	1

instruments of operating room

Shadowless lamps should be equipped according to the operating room size and operation requirements, multi-head type should be adopted; The position of the adjusting plate should be above the air supply surface, and the distance from the air supply surface should not be less than 5cm.

The length of the operating table should be arranged along the long axis of the operating room, and the center of the table should be corresponding to the center of the operating room floor.

Anesthesia timing, operation timing and general clock timing should be used for operating room timers. Operating room timers should be clearly marked with hours, minutes and seconds, and equipped with a timing controller.In case of power failure, the self-provided battery can be automatically connected, and the power supply time of the self-provided battery should not be less than 10h. The timer should be set above the wall that is not easy for patients to see, 2m away from the ground.

The medical air source device should be set on the ceiling on the right side of the patient's head on the operating table and on the lower part of the wall near the anesthesia machine, with a height of 1.0-1.2m from the ground. The anesthetic gas discharge device should also be placed on the operating table side of the patient's head.

The number of viewing lamps can be configured according to the size and type of operating room. Viewing lamps should be set on the opposite wall of the operator.

The device cabinet and medicine cabinet should be embedded into the convenient position within the side wall of the patient's foot; The anaesthesia cabinet should be inserted in a convenient position within the patient's cephalic vein.

The infusion guide (or hook) should be located on the ceiling above the operating table, parallel to the long side of the operating table, with a length greater than 2.5m, and the orbital spacing should be 1.2m.

The recording board is a dark plate with a length of 500mm and a width of 400mm. The large recording board is 800mm long and 400mm wide. When the recording board is opened, it should be 1100mm off the ground. It should be folded up and flush with the wall. If the cleaning, disinfection and sterilization device cannot be set up in the operating room, it can also be centrally set up in the preparation or disinfection room of the operating room. If a heating and cooling cabinet is needed, it should be set in the medicine room. The temperature of the refrigerator is 4+2℃ , and the temperature of the warm cabinet is 50±2 ℃ .[32]

The equipment embedded in the wall shall be flush with the wall, and the cracks shall be coated with glue; or its front four sides should do stainless steel flanges.

3.4.4 Module design of clean operation department building space

3.4.4.1 Principles of module design for clean surgery

The department of clean operation is a comprehensive department with complex technology and high degree of cleanliness.The study of its architectural system design principles has been the direction and focus of architects' research for many years.The contents of the principles of induction and summary specifically include the following points:
(1) Satisfy the requirements of medical streamline within the department of clean surgery.
According to the above, the medical streamline inside the clean operation department is the original requirement and foundation of the design, and its existence stipulates the medical behavior mode and the principle of plane layout in the clean operation.Specifically, the internal medical flow line is finally concentrated in the clean operating room, a total of six flow lines in and out of the clean operating room.The requirement of medical flow line for clean operation department is actually the reasonable arrangement and arrangement of these six flow lines, and meet the requirements of clean operating room.

(2) Satisfy the requirements of infection control.
The so-called infection control, is to clean the surgical department of thedivision, has achieved the control of the cleanliness of each district.In the plan layout of the clean operation department, all rooms should be divided according to their cleanliness.The specific space composition and infection control requirements of the clean operation department are the basis of the plane layout of the clean operation department. Due to the different connections and cleanliness of each functional room, these rooms must be combined and partitioned according to certain rules between each room to form a reasonable and economic clean operation department.

(3) Satisfy the space size of each functional room building module of the clean operation department.
The building space determined by the net size of the internal building space should meet the requirements of the surgical medical behavior and the placement of medical equipment.It is mainly from the two aspects of personnel activities and equipment placement comprehensive influence, so as to determine the space scale of each room

building module inside.

(4) Select a reasonable model combination of standardized modules for the clean operation department
At present, there are mainly five combinations in the world, which are: one-row permutation, multi-row permutation, unit permutation, loop-shape or C-shape permutation, mixed permutation and combination.These combinations are applicable to different building plane forms, and the above five combinations should be selected according to the specific location of the clean operation department.

3.4.4.2 The plan layout of the clean operation department

The plan layout mode is the basic framework of the module of clean operation department.The significance of the plan layout of the clean surgery department lies in the understanding of its current relatively reasonable plan layout mode through the combing of the medical streamline and the basic principles of layout. An economical and suitable plan layout model for the clean operation department will become the basic guidance condition for the module composition of the clean operation department.

-Basic principles of plan layout
The main purpose of building the clean operation department is to provide a sterile and clean operating environment and reduce the incidence of infection during the operation. The clean area and contaminated area can be separated by the layout of clean operation department to prevent cross infection. Therefore, the flow of personnel and items in the department of clean surgery has become a key reference factor in the design of the plane layout, which is also a response to the central idea of infection control design in the department of surgery. In conclusion, the plane layout of the clean operation department should be considered from the aspects of inlet diversion, internal and external corridor diversion, and pollutant nondiffusion arrangement.

The idea of pollution control will become the most important consideration and be reflected. Different countries have different understanding of control ideas and emphasize different control emphases, resulting in different arrangement of inlet diversion, internal and external corridor diversion, and pollutant nondiffusion. There is also a wide range of layout patterns, both recommended and customary.

-Clean operating room space combination
In the design of clean operating room space combination form, mainly in order to meet the clean operation department in the design of the flow between the shunt to achieve, generally a large number of clean operating rooms are simply arranged side by side, around the clean operating room set cleaning corridor, can form a complete operating unit. This arrangement is common in major hospitals.

Different schemes and practices have also been adopted in various countries for the combination of clean operating rooms.For example, in European countries, the clean operating room assembly has its own way and a high design standard. Before the operating room, there are several front and back rooms, including the toilet, anesthesia room, instrument room, sewage washing room, disinfection room and so on.And form a complete surgical unit.This arrangement focuses on each functional room to improve work efficiency.

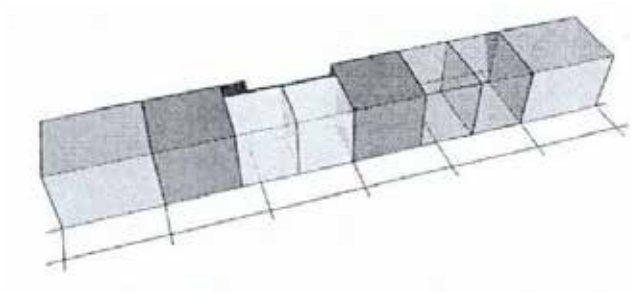
In China, according to the actual national conditions, the operating room is traditionally connected with the corridor instead of the front room and the back room. Anesthesia before the operation is completed in the operating room. Usually, there are three or four operating rooms in a group, and each group is equipped with a toilet and a temporary washing and disinfection room.Most experts think that only this arrangement is the most economical and reasonable, and can meet the requirements of the clean operation department at this stage.It has become the mainstream of the plan layout mode of the clean operation department.

3.4.5 Model combination mode of module in clean operating room

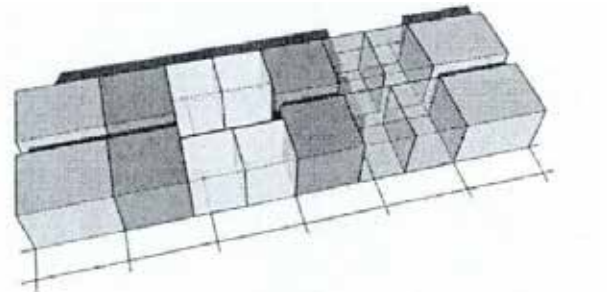
The clean operating room is the most important core functional space in the clean operation department, namely the core area of the operation.Its modular building model combination mode will become the plane form of the clean operating room and has a decisive influence. The modular building model combination mode in the clean operating room mainly includes five combination modes:[32]

(1) one-row permutation and combination;
(2) multi-row permutation and combination;
(3) unit permutation and combination;
(4) zigzag or C-shaped permutation and combination;
(5) mixed permutation and combination.

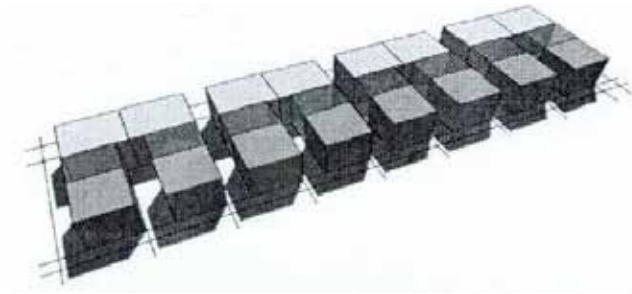
These combinations constitute a common arrangement in the clean operating room today.



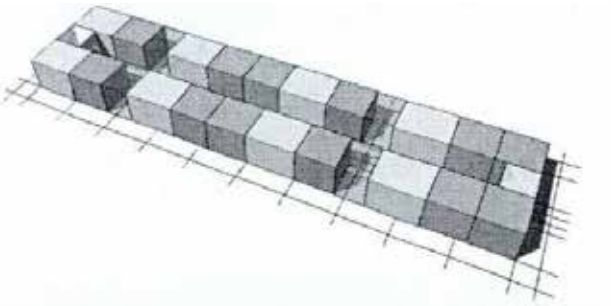
One-row permutation and combination



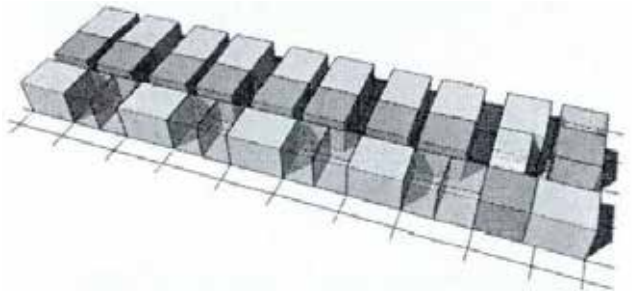
Multi-row permutation and combination



Unit permutation and combination



Zigzag or C-shaped
permutation and combination



Mixed permutation and combination

Five combination modes[32]

3.5 Analysis of the characteristics of architectural elements on the space design of outpatient building

This chapter takes the space of outpatient building of a large general hospital as the object of study, including the external public space of the outpatient department and the internal space of the outpatient department, among which the internal space of the outpatient department also includes the public space and the exclusive functional space.

3.5.1 Outpatient department classification and space

Outpatient service is an important part of the building of large general hospital. It is a part of the building where people have more contact and visit. The outpatient building contains different types of outpatient departments, such as internal medicine, surgery, pediatrics, gynecology, neurology, etc. The larger the scale of the general hospital, the more detailed the departments.

According to the types of out-patient clinics can be divided into general out-patient, day out-patient, health out-patient and emergency outpatient. Their respective features and functional requirements are as follows:
(1) General out-patient service: General out-patient service can be divided into appointment out-patient service and non-appointment out-patient service according to their coming to the hospital.Outpatient booking system can avoid a lot of focus of clinic patients, at the same time can be shorten the waiting time, reduce the crowded situation, the current European countries hospital more emphasis on appointments, while China is to make an appointment after diagnosis, the doctors think when the patient is necessary to return to from the pre-hospital do good on the next appointment booking procedure, also can phone booking.The general outpatient service and the health care outpatient service are in the specified time, some hospitals have begun the holiday, weekends as usual consultation commitment, in the outpatient peak season to extend the appropriate consultation time, in order to facilitate patients.General outpatient department settings, corresponding to a branch of the inpatient wards in general hospital in general according to the local disease conditions set different size of outpatient department, such as internal medicine, surgery, pediatrics, obstetrics and gynecology, ophthalmology, facial features, oral cavity, skin, such as Chinese medicine clinical departments, and independent or associated with inpatient configuration radiation, inspection, department of medical and pharmacy, etc. The general out-patient is the main body of out-patient service, whose out-patient person-time and the area occupy the larger proportion.

(2) Day outpatient service (not day-hospital): As a new and effective diagnosis and treatment mode, ambulatory-day outpatient service is a new type of medical service tailored for patients with common diseases and frequently-occurring diseases that require short-term hospitalization and observation. It can alleviate the pressure of outpatient service and hospitalization, meet the social needs, and further improve the quality and efficiency of medical services.It has the advantages of reasonable resource optimization, effective cost saving and patient expense saving.

(3) Health outpatient service: The health clinic is generally the clinic for preventive examination and health knowledge consultation and guidance. Its main work content is regular health examination, premarital examination, cancer prevention, caries prevention,

and health care for women and babies.In the future, with the improvement of people's cultural level and economic level, there may be a greater increase in the demand for consultation on eugenics, eugenics, health and health care.

(4) Emergency outpatient service: it is specially for patients whose condition is urgent and must be treated and rescued in time. It is usually open 24 hours a day to receive emergency patients.

The scope of study in this chapter is the outpatient department space of a large general hospital, including the general outpatient department and the emergency department, excluding the day outpatient department and the health outpatient department.

We divide the outpatient building space into two types: exclusive functional space and public space.The public space is divided into the external public space and the internal public space of the outpatient building.

Exclusive functional space: the space is not open, but the use space for patients to receive diagnosis and treatment or doctors.The patient receives the diagnosis and treatment space is the consultation room, the treatment, the dressing room and so on;The doctor's use space includes the doctor's office, the classroom, the logistics auxiliary space and so on.The exclusive space realizes the contact between doctors and patients through the consulting room, treatment room, dressing change room, etc., but it is also the office space of doctors, and the exclusive space is the working area of doctors, mainly the working, learning, communication, activity and rest space of doctors, nurses and other staff. It is the "surplus" of the public space.

Public space: Public space has a certain openness. It is a place to provide the public with certain open social activities. It is not a space restricted to specific groups.The public space of a large general hospital is an open space that focuses on medical treatment and takes care of relevant people, including the square in front of the clinic, lobby, waiting room, transportation, rest and communication, courtyard, public service space, etc.

3.5.2 Outpatient department space structure, streamline and characteristics

3.5.2.1 Outpatient department space structure and streamline

The outpatient building of large general hospital has complex functions and various Spaces. People's behavior choices and ways are different in different types of Spaces. Space is a container closely related to people's work and life."For large general hospital outpatient service building space, first should be a systematic classification of outpatient service building space from macroscopic to microcosmic, from whole to part of the longitudinal, horizontal partition according to different service function, progressive, step by step to understand the position and function of every space in the whole space system, establish the basic concepts of different types of space."[33]

-The spatial composition of the outpatient department
As a part of urban public space, medical building space occupies a large proportion in urban public space due to its huge medical space.Medical building space by outpatient service building space, ward building space, medical building space and administrative space, logistics and other components of the space, including outpatient and ward floor between the most contact with the urban public space, contact more closely, the two kinds of space through the square, roads, etc as a buffer to receive large crowds from urban public space, so the higher requirements of space.Compared with the inpatient outpatient building, the number and types of people admitted every day are various, and its architectural function and technology are complex, with a large number of people coming in and out every day, which makes it more difficult to manage than the ward building. Therefore, the classification and composition of the outpatient building space should be clearly understood.

First of all, the outpatient service building space subdivision, according to the space is divided into the clinic building internal space and the outpatient service building outer space, outpatient service building internal space surrounded by the outer space, interior space is also the outer space is outspread, building palisade structure for the space space partition boundaries will be two different areas, the boundaries can be not obvious, sometimes make harmony inside and outside space.

Second, according to space type of points, outpatient internal space is divided into public space and special functional space: the public space of the service object is mainly hospital outside the crowd, people can choose the appropriate places designated public behavior, by the space order and public morals, law, system of self-consciousness, the hospital internal conditions such as constraints.There are many constraints on people's behavior in the internal public space. The publicity of the internal space is divided into strong and weak, so it is necessary to build specific places of activities to effectively organize the space order. Exclusive function space is the main service object of hospital staff, only the clinic therapeutic, dressing room specific medical space such as open to the public, is a doctor diagnose diseases, communicate directly with patients, other space for auxiliary office space, do not open to the public, is the area of activity and staff work, privacy is stronger;Compared with the internal space, the external space of the outpatient department has a strong public character. Combined with the urban public space, it plays a transitional role between the urban space and the internal space of the outpatient department. People can conduct activities in the external public space and generate public behaviors.

Finally, according to functions, the public space inside the clinic is divided into waiting space, rest and communication space, resident space, traffic space and green space.The public space outside the clinic is divided into activity space, traffic space and green space. Each space has its own service function, providing specific activity space for the crowd, planning people's behavior pattern, causing people's psychological and emotional changes and affecting people's psychological feelings.In the following paragraph, we describe the process followed in Chinese hospital.

-Relationship between outpatient building and other departments
(1) Internal flow of medical treatment in the outpatient building
People enter into the internal space of the outpatient building through the entrance and exit of the outpatient department. Some of the patients can directly go to the outpatient department for follow-up examination, but for the patients who are newly diagnosed, triage and registration are required before they can enter the relevant departments. In the following paragraph we describe the process followed in Chinese hospitals:

After the diagnosis of relevant departments and the auxiliary examination of outpatient medical technology, the doctor shall make a price according to the patient's medical treatment and specify the content and relevant expenses of the patient's treatment.After that, the patient goes to the designated place to pay the fee, get the medicine, and finally get out of the outpatient department. This is the general flow line and the overall process for ordinary patients to go to the outpatient department for treatment.

This is the process actually followe in Chinese hospitals. In many European countries the consultation is planned by a doctor of the territorial service or of the hospital.

A) Triage and consultation: after entering the hall, people go to relevant departments for medical treatment through triage.Outpatient service branch is more and more detailed, a lot of people do not know about their own situation leads to do not know which department to go to see a doctor, registration error, registration referral and other situations sometimes appear to make the physical condition of the patient more worried.If infected patients are not accurately and timely sent to the relevant departments, it is easy to have a negative impact on the health of the rest of the outpatient population.Experienced doctors or relevant staff in triage can make timely and effective judgments based on the conditions described by patients, conduct triage for patients who are newly diagnosed, and guide patients to relevant departments.

B) Registration: In China, there are more and more forms of registration, including centralized registration, sub-division registration and online reservation registration.Most general hospitals implement centralized registration for the convenience of management and full use of space, etc., but centralized registration will make a large number of people concentrated in the registration desk, resulting in traffic congestion, long queuing and other phenomena.The sector-by-branch registration can make the flow of people entering the clinic be separated as soon as possible, so that the triage crowd to the relevant departments for registration as soon as possible.In addition, with the update and development of electronic devices, online reservation registration is becoming more and more popular. People can register online in advance through the Internet, avoiding the link of queuing for registration in the outpatient department, and greatly reducing the time for medical treatment.

C) Charge for drug collection: like registration, there are three modes: one is centralized charge for drug collection, the other is charge for drug collection by branch, and the third is the mode of existing concentration and branch co-existence.The third mode, which is humanized, reasonably assigns patients to pay for drugs in designated places according to department functions and patients' specific conditions.
(2) Streamline between the outpatient department and the medical technology department
People receive a preliminary diagnosis in an outpatient setting and enter the technical department if further diagnosis is required. The outpatient population flows to the medical technology department mainly for examination, assay and treatment, among which the examination department and radiology department of the medical Technology department receive a large number of outpatient patients, so the medical technology department and the outpatient department should maintain convenient and fast contact; More than half of the people in the medical department come from the outpatient building and the rest from the patients in the wards.After the medical technology department has been examined, most of the people from the outpatient department still have to return, so there is a high turnover of personnel between the outpatient department and the medical technology building, and the accessibility and accessibility of the channels connecting the two have higher requirements.

(3) Streamline between outpatient department and ward department
The main source of patients in the ward building is the outpatient department. Most of the out-patients will leave the hospital after the completion of diagnosis and treatment, while the rest of the patients who need to be hospitalized will be transferred to the ward building. The connection between the two is controlled by the patient flow line.Patients entering the ward building rarely return to the outpatient department, so in order to improve traffic efficiency, the two should be more direct direct contact.

-Spatial characteristics of the outpatient department
Large general hospitals belong to urban public buildings, which provide relevant services for urban people and solve work and life problems for urban people. In addition, medical buildings are highly professional and assume special functions in the city.The space of outpatient building in a large general hospital is affected by the publicity and special functions of the hospital. The following is a list of some characteristics of the space according to the functions and tasks of the outpatient department and its own physical attributes.

(1) Openness
The space part of the outpatient department is open, providing the patient with space for activities.The daily visits to the outpatient building of a large contemporary general hospital are increasing, and the openness of its public space is becoming more and more obvious. In order to meet the needs of patients, the modern outpatient department has an open space, an open way of use, an open communication of information and an open attitude of service.The open space is convenient for people to communicate, timely obtain relevant information and improve people's anxiety, which is conducive to improving the efficiency of people's medical treatment and the working efficiency of doctors.The nature of the open space is convenient to alleviate the contradiction between the hospital and the urban space and people, and it shows the tolerant, generous and accepting space attitude of the outpatient building.

(2) Specificity

The work space of the staff inside the outpatient department has the specificity, which includes doctors, nurses, logistics personnel, administrative personnel and so on. The specificity of the space guarantees the work quality and efficiency of the staff.This part of the space is not open to the outside world. Only the room space where patients have direct contact with doctors is semi-external, but it belongs to the working space of doctors, which has great restrictions on the public behavior of patients. The space for logistics and administrative staff is also exclusive and does not allow for patient intervention.

(3) Directivity
Hospital building departments are numerous, hospital streets and lanes cross to form a number of intersections and traffic nodes, people are easy to get lost in the traffic. Therefore, providing people with a space environment that is easy to judge the direction is the primary premise of building design of large general hospital.The external space of the outpatient department should also have a certain directiveness in order to guide the flow of people and traffic. Different types of streamlines in the external space are easy to cross and interfere with each other.

(4) Spatial accessibility and accessibility
In modern large-scale general hospitals, each department is more and more closely connected with each other, with the purpose of shortening medical process, saving medical treatment time and strengthening the overall operation of each department.The streets in the space of the outpatient department become the channels to contact other departments, and the space has accessibility and accessibility.Accessibility and accessibility can not only help patients to reach each area of the outpatient department, but also provide a relatively fast route to the inpatient building and medical technology building.

(5) Networked, digital and intelligent space
In China, in order to improve the efficiency of space management and use of outpatient buildings, the use of networked, digital and intelligent equipment in space is becoming more and more popular and becomes a trend. With the extensive expansion and use of the network, digital and intelligent communication makes the channels of obtaining information more diverse, the speed of understanding information more rapid, the way of exchanging information more convenient.With the assistance of computers and other electronic equipment, the clinical operation of modern hospitals has all realized paperless operation: all kinds of information such as patients' registration, diagnosis cases and examination results are accurately and completely stored in the electronic database.Both the electronic display and the intelligent inquiry system in the space can provide timely help to the patients.Intelligent electronic display can also use the outdoor space to help guide the parking order. People can understand the parking space surplus through the electronic screen, there is no need to waste time and drive to deliberately find parking Spaces. With the assistance of electronic equipment, people can save energy and time. With the progress of science and technology, the network, digital and intelligent technology in the outpatient building space is gradually popularized and applied to more aspects so that all aspects of information can achieve visual effect, and the space function will be more perfect.

3.5.3 Analysis of activity crowd type in outpatient department

Huge crowd in large general hospital outpatient service building space, every day there are all sorts of people in outpatient service door, according to statistics, in China, not including the hospital staff, patients accompanied by personnel number is the number of patients 1 to 3 times, that is to say, not only to hospital patients, followed by and accompanied by a large number of family members of the staff.The space of the outpatient department should not only serve the patients and staff, but also provide relevant services for other more types of people, who belong to the users of the space. Therefore, it is extremely necessary to classify such a large group of people for the research of space design.For designers, to determine the purpose and task of different types of people's behavior in space is an effective means to explore the use function of space and to divide space regions.

The building of the outpatient department is mainly built to ensure the smooth progress of patients and doctors' diagnosis and treatment. Therefore, patients and medical staff are the main users in the space of the outpatient building.Compared with medical staff, patients are the most important service objects. Patients belong to the vulnerable group in the population, and they need comprehensive care and care. It is also the work category of medical staff to provide timely services for patients.Secondly, medical staff are long-term users of the space in the outpatient building. The space provides the working environment for medical staff, which has a direct impact on the working efficiency and working mentality of medical staff. Therefore, the space design should also meet the behavioral and psychological needs of medical staff.

Managers and logistics service personnel are a group of people centering on medical treatment. They complement the work content of medical staff and jointly provide good services for patients. They are hospital staff and work in the same working area with medical staff, so they can enjoy the working environment at the same level as medical staff.

In addition to patients and hospital staff, patients' family members are relatively secondary to the first two users. Their role is to assist patients at home to successfully complete the whole process of seeing a doctor, which plays a great role in protecting patients.Family members also frequently refer to the relevant space areas used by patients to assist with medical treatment.However, if the relationship between family members and space is not well handled, it will have a negative impact on the medical treatment process of other patients. Therefore, in addition to the fact that patients are the highest priority users in the space, the family members and medical staff of patients also pay enough attention to the space requirements.

Through analysis, the spatial population of outpatient buildings in large general hospitals is classified into three categories: patients, hospital staff and patients' family members. Patients are the main service group in the space, followed by hospital staff and patients' family members.

3.5.4 Design strategies of outpatient department

3.5.4.1 Design strategies of public space inside the outpatient department

-Design goals
(1) Establishment of space security
Public space design first needs to guarantee the safety, including the physiological safety and psychological safety of human beings, which is the most basic requirement of "humanized" space design.A large number of patients are in the public space, and the traffic phenomenon of walking shoulder to shoulder often occurs, so the safety of the space is particularly important for those patients with mobility difficulties and physical weakness. Barrier-free facilities should be set up in the space to provide a safe and convenient traffic space for the disabled. Railings and handrails should be set up in accident-prone areas, such as places with footfalls and height differences, so that people can enjoy a sufficient sense of security when using the space.Too large a space is easy to make people feel fear and oppression, and easy to cause the disorganization of traffic, make people lose the sense of security, so every part of the space needs reasonable planning and design, make the space order in good order.

(2) Establishment of spatial comfort
The space should improve its comfort while ensuring safety, including the improvement of physical environment and the construction of beneficial psychological environment. In the public space of outpatient building, comfort is the goal of people's common needs. For patients, family members and staff, the space should not only meet their most basic demands of seeing a doctor and working, but also strive to improve their own quality, so that people can feel the relaxed atmosphere of life in the space.Sufficient sunshine, elegant rest space, beautiful green, full of life atmosphere of shops, shops and other relevant humanized space can make people feel the place with perfect function and relaxed atmosphere.From the perspective of "humanization", space should not give people more and more care, so that people can use the least time and money for the greatest comfort. Comfortable space atmosphere is not only welcomed by people, but also has a beneficial impact on the health of patients, which is the goal of space design.

(3) Establishment of spatial identification
For the users of the outpatient building space, they hope to have clear identification and orientation in the space, so as to complete their space positioning and quickly reach their destination.Modern large comprehensive hospital complex spatial relations, spatial type is various, sometimes vertical and horizontal transportation is easy to make the person produces the spatial resolution is not clear, because the public space in the intersection of local similarity degree is higher, people tend to lose their sense of place, therefore provide people with an easy to identify the space environment is particularly important.First of all, the space should maintain a clear logical relationship. The traffic system in the space should be clear and conspicuous. The connection mode is simple and the circuitous traffic route should be avoided.Secondly, in the space, color and node landscape light visual modeling can be used to divide the space region, so as to clarify the spatial characteristics of each region and establish people's sense of orientation in the space.In addition, different levels of indicators can be set in the space, the type and level of identification can not be too much, so as not to confuse people, identification can provide people with relatively clear spatial information, according to different levels of identification to determine their position in the space.

4) Establishment of space domain
Space is different from each other, thus forming their respective fields. The formation of fields also leads to the division and division of space, so that each space maintains its own characteristics and does not interfere with other spaces.There are many ways and means to form the domain, and in the public space, the space is enclosed in different degrees. The elements that surround the space include ceiling, greening, railing, partition, etc. In addition, the placement of furniture can also create a sense of domain in the space. For example, the relative placement of seats can produce introversion; on the contrary, if the seats are placed back to back, it will produce extroversion, which will destroy the sense of domain. Sense in the establishment of the public space is needed, because the space in the masses, to the activities of different space types people need different, activity demand sometimes quiet or public, sometimes it is small or groups or private, according to the needs of different behavior, space will be divided into definite areas make the space produces a variety of purposes. Sometimes the emphasis on the spatial domain is actually the emphasis on the sense of space and place. The domain makes the space more specific and functional, including the meaning of people engaging in one or several activities in it. Emphasizing the domain of public space is a positive reflection of people's social activities and psychological requirements. It is one of the important contents that cannot be ignored in space design.

(5) Establishment of a sense of space and place
The establishment of the sense of place will make people choose corresponding spatial behaviors spontaneously, which is an effective means to organize people's behaviors. Form certain place atmosphere in particular space, let a person distinguish the function of the space and use clearly, undertake reasonable use to the space, reduce the chaos in the space. For example, waiting space, horizontal traffic space and rest space all need to establish a certain degree of order, among which waiting space has a high requirement for order. The space design should help to form order, so that people can queue and wait in the space in perfect order to reflect the features of waiting space.

-Design way
(1) Design of waiting space
People's behaviors in waiting are very similar and require high spatial order, so the order is very important. People with similar psychological properties are integrated to make them wait in a space with a strong sense of order. People's waiting behavior can be divided into two ways: linear waiting and centralized waiting:
Linear waiting - People form order by queuing up in a vertical line in space. In linear waiting mode, it is easy to cause disputes among people due to queue-jumping and crowding, resulting in disorderly and disorganized queues and chaos of spatial order. The space can be arranged guardrail, handrail and other facilities to maintain the space order. According to the behavior characteristics of linear waiting people, the queue can be distinguished by ground decoration, and "one-meter line" can be drawn in the waiting window position to prevent a large number of people from piling up in the window position.

Centralized waiting -- the corresponding fields are divided from the space to induce people to gather together and wait in a specified area. The space provides a place where people can sit and wait.In the site, seats can be arranged or space can be enclosed to create an orderly place for users to wait. On the choice of seat, people are more inclined to pull over a seat, sat in the middle, people will feel crowded inconvenience, so the number of seats side by side shoulds not be too many, too many side by side of the seat will produce the

inconvenience of traffic behavior, and in the central position of the seat on both sides of the low utilization rate, so the seat arrangement generally three or four rows is advisable. Centralized waiting should be combined with linear waiting design. The single waiting method has its limitations.

waiting space of Beijing Youyi Hospital[33]

This chapter takes the space of outpatient building of a large general hospital as the object of study, including the external public space of the outpatient department and the internal space of the outpatient department, among which the internal space of the outpatient department also includes the public space and the exclusive functional space.

(2) Design of rest and communication space

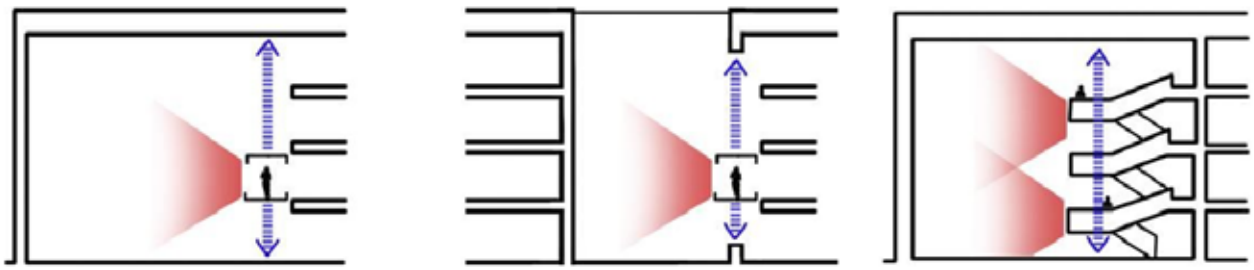
The rest space in the privacy design sometimes has the higher request.Privacy is the core of the design of the rest space. It provides security and selectivity for the users of the space and ensures that they will not be disturbed by the outside world when communicating. Privacy is not only for individuals, but also for groups, who form small groups and do not want the outside world to know about them.In the public space, people have a relatively free way of communication and a relatively open conversation, so it is not suitable for people to rest or have private conversations in open places. The places specially designed for people to rest do not want to be disturbed by the outside world. It is hoped that there will be a shelter to help maintain the quiet atmosphere of the rest space, even if the shelter limits the space.Therefore, the rest space design should adopt the form of aggregation, convergence and centripetal, rather than the form of divergence, diffusion and outward.

(3) Traffic space design

Horizontal traffic space design should be closely related to the surrounding functional space and ensure its accessibility. Shortening the length of horizontal traffic, increasing people's walking accessibility and mobility efficiency become the focus of the design;Secondly, public horizontal traffic should be designed for traffic microcirculation when necessary, especially around departments with relatively large visits in the outpatient department, which can induce rapid evacuation of people flow and relieve traffic pressure in the hospital street.In addition, the level of traffic will be untied the outpatient service building the space together, ensure smooth level traffic users to walk in space should be paid attention to when its area is enough space for traffic guiding role, reasonable distribution of the area of the reside space, also can rest space layout, use of other space limit and space greening of traffic guidance, to prevent the people to get lost in the big traffic space;When the area is insufficient, should ensure the function of traffic space itself

above all, do not intersperse combination with other space as far as possible, otherwise not only cannot realize the superposition of function and increment but bring obstacle for normal traffic instead.The horizontal traffic with a small area lacks the location of residence space, so it can be considered to break the boundary of horizontal traffic and add a part of "protruding" space. This part of space can allow people to stay temporarily and reorganize their behaviors without blocking the advancing stream of people in the traffic, so as to ensure the smoothness and interest of traffic.

Vertical traffic in public space is mainly divided into stairs, escalators and elevators.The elevator can be combined with the design of lobby and atrium space to provide the users with a broad vision and good light. People can also perceive the space through vision in the elevator. The open line of sight is more conducive to the adjustment of people's psychological mood than the closed one, and the height and position of their space can also be determined.Stairs and escalators are usually combined with the design of hall space. Both stairs and escalators can be used as architectural walking paths, which play a guiding role for people to walk. People's perception of space changes with the change of location in the process of traffic and experience the spatial form.The staircase can make full use of the rest platform to provide residence space for people, in which facilities such as greening can be arranged to help improve the quality of the space, people can talk and exchange on the rest platform and temporarily rest.It is recommended to adopt the crossover type for escalators. The upper and lower flow lines are set alternately at both ends of escalators, so that the upper and lower flow lines alternate and do not interfere with each other, avoiding people going up and down in the same direction and reducing people's detour routes, so as to improve the vertical traffic efficiency.The oblique lines of stairs and escalators break the horizontal and vertical sense of the hall, increasing the sense of spatial levels and three-dimensional sense.



a)elevator intergrate with lobby and atrium[33]

b)staircase intergrate with the lobby[33]

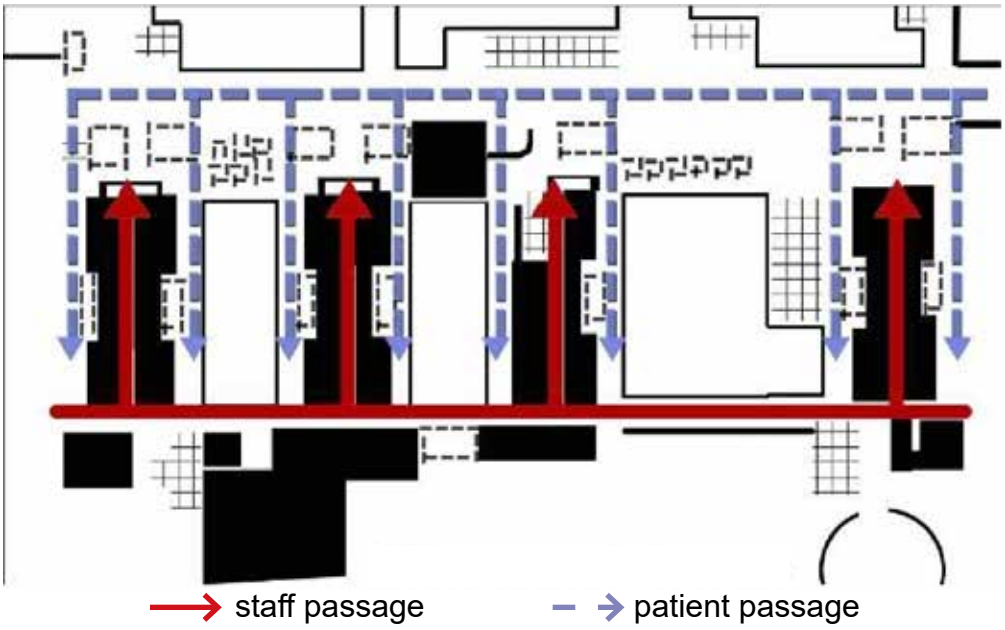
Elevators, stairs, escalators in keep its function on the basis of the traffic can be combined with rest, greening and other space design, make traffic space no longer monotonous, play to the potential function, the way of the combination of the different space "value-added" function, different function space after optimized integrated into an organic whole, not only promote the space diversity, also prompted changes in consumer behavior, enhance space interesting, played the one plus one is greater than two, the effect of increasing the space efficiency.

3.5.4.2 Design strategies for exclusive functional space of outpatient department

The exclusive functional space of the outpatient department is the working and living area of the hospital staff. We roughly divide the exclusive functional space into two types: consulting rooms and office, rest area for staff.

-Design goals
(1) Independent
From the perspective of spatial layout, each department is less open to horizontal traffic space. Department rooms are open to the public space point-like by door, so as to exert strong control over the flow of people entering the department. In addition, doctors' offices and doctor's rest rooms are sometimes not in contact with the public space, forming different fields with the public space.The independent department arrangement is conducive to the distinction between public and exclusive functional space. The working environment of doctors is less disturbed by public space, and the privacy of doctors is effectively protected, forming a dedicated working and living space for doctors.

(2) Doctor-patient triage
The doctor-patient flow is an important principle for organizing the spatial flow of the outpatient building. The staff flow should be separated from the patient flow, so that the space creation can meet the behavioral and psychological needs of different groups of people, and the space can be attached with a specific sense of place and characteristics. Elevators and passageways for staff should be set up in the exclusive functional space, which is different from the mode of transportation used by patients.Doctor-patient diversion can improve the traffic efficiency and work efficiency of staff, which is one of the design principles of "humanization". For example, Wuxi Medical Center thoroughly implements the doctor-patient separation to every outpatient department.



depart flow lines in Wuxi medical center(D program)[33]

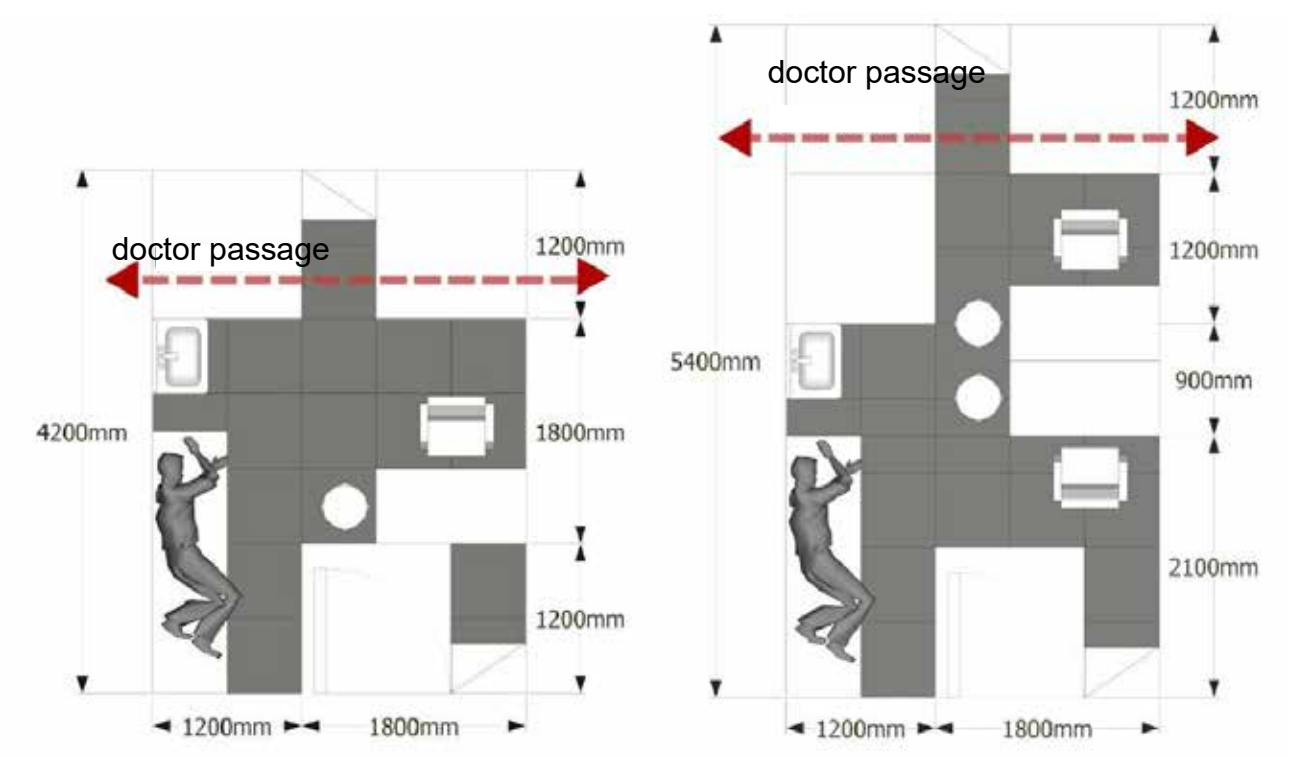
-Design way
(1) Requirements for space layout of the general consulting room
As an important part of the outpatient department, the internal space layout of the consulting room should also have the concept of functional division, medical flow and

streamline division.There should be doctors' activity area, doctor-patient consultation area and doctor-patient examination area in the space, and there should be corresponding medical activity area, diagnosis platform area and diagnosis and treatment bed area.

The basic configuration in the consulting room: diagnosis desk, viewing lamp, computer, diagnosis bed, lavabo, dirt bucket and chair, etc.Because of the digitization of the information system, the information terminal is the necessary equipment in the clinic.The lavabo is a necessary facility to wash hands at any time after examination and ensure the health and safety of doctors.The examination bed is a necessary facility for the patient to receive examination.Some items that patients sometimes carry with them need to have a certain storage space, and they may need to change clothes during the examination, so patients need to have a change space in the clinic;In the process of seeing a doctor, the accompanying family members also need to enter the clinic to help describe the illness and assist the doctor to do the examination. Therefore, if possible, the accompanying family members should have a space in the consulting room.

(2) Consulting room space scale
The outpatient consulting room is a basic medical space where doctors inquire, examine or use simple and small medical instruments to diagnose and treat patients' conditions.Its medical behavior revolves around the diagnosis table and the diagnosis bed.

In China the minimum size of the consulting room is 3m, and the depth is 4.2m[33]. The size can be increased according to functional requirements. If other functions or channels are considered at the back, the depth can be enlarged. One or two desks can be set up in the department.



the space scale of single and double consulting rooms[33]

(3) Auxiliary room design

Auxiliary office space refers to the dedicated staff space such as doctors, nurses, lounge room, in the classroom, the dressing room, office, etc., these spaces are relative to the professionalism of the weaker office space, but these space "humanized design" are also important, staff personnel is the hospital long-term users, work environment directly affects their work mood and state of mind when they work will have a big impact on the patients. Therefore, the design of the auxiliary clinic space should be considered according to the psychological needs of the staff. In addition to the location away from the patient, it should be located where the patient cannot see, and the principle of proximity and division should also be considered.

3.6 Analysis of the characteristics of architectural elements of the efficiency in the emergency department

The emergency department, also known as the first aid department, is an independent department with the most intensive critical patients, the most kinds of cases and the most serious rescue tasks in the hospital. The emergency department, which is in the first line of saving patients' lives and dealing with all kinds of acute and critical diseases, is the necessary department for all emergency patients to be hospitalized. The emergency department of the general hospital has specialized offices in medicine, surgery, paediatrics, obstetrics and gynaecology and ent. Thus, the overall work of the hospital is concentrated in the work of the emergency department, which reflects the efficiency, quality of work and the level of medical staff. Modern emergency medicine has gradually developed into a trinity emergency medical center and emergency medical research center for emergency, first aid and intensive care, which can implement a one-stop first aid service for critically ill patients. [3]

3.6.1The importance of efficiency in a general hospital emergency department

Emergency department is a multi-specialty clinical independent discipline emerging in the past 20 years.[3] It has the characteristics of emergency, comprehensiveness, risk and continuity. The patient's condition is critical and needs to be treated as soon as possible. The main characteristics are as follows:
(1)A large number of people, the flow of people concentrated and multifarious activities.The main stream of people in the emergency department is the general emergency patients and the patients needing rescuing.The mixture of patients, accompanying family members, medical consultants and medical staff reflects the complexity of the flow of people.

(2)The internal function is complex, the need for a strong direction and identification.

Because the flow of people in the emergency department is complex and concentrated, the architectural design mainly focuses on shortening the length of the flow line and improving the recognizability. In this way, the phenomenon of patients and medical staff interweaving in each department can be reduced, thus reducing the flow congestion and confusion. In the architectural design, it is necessary to set up appropriate waiting space and arrange clear flow line.

The biggest purpose of emergency department is to give first aid and relieve the pain of patients, so most of the patients come to the hospital have difficulty in movement or physical discomfort, at this time to the patient queue waiting for treatment, back and forth inspection, receive a report, it is obviously inappropriate.Long waiting times in the emergency department can lead to overcrowding and increase disputes and dissatisfaction. Other factors (functional and environmental layout of the building, first aid procedures, guidelines and signs, service facilities) also contribute to the dissatisfaction of emergency patients.The phenomenon of delay in treatment of critically ill patients who need timely rescue in the queue of waiting for treatment occurs, resulting in no emergency and low efficiency of emergency treatment. And in the epidemy of covid-19 has been evident in the European experience the need to divide the access to the emergency unit from infectious inspected people from the others.

3.6.2 Analysis of architectural design factors

This chapter studies the influence of architectural design factors on the efficiency of emergency department, which is also one of the factors that have more influence on the efficiency of emergency department among objective factors. The following is a case analysis and comparison of architectural design factors from the aspects of spatial organization, emergency procedure, traffic organization, functional streamline, etc.

3.6.2.1 Spatial organization model

As the main department of hospital rescuing critically ill patients, the emergency department is relatively independent. Because the patients in the emergency department have the characteristics of emergency and critical condition, the traffic flow line in the emergency department should not only be smooth and convenient, but also the entrance and exit should be set separately with obvious signs. Meanwhile, the entrance and exit should be equipped with ramps to ensure the convenience of main vehicles.The most important is a reasonable spatial organization pattern and layout, which has a great impact on improving the efficiency of medical treatment. Following Chinese technical rules:

-The pattern of internal space composition in the emergency department

(1)The spatial composition of the emergency department

The space of the emergency department of a general hospital is mainly for medical technology, first aid, diagnosis, treatment and observation, and also includes public space and ancillary space.The departments are equipped with a large area of the consulting room, laboratory, treatment room, registration fees and the emergency room, operating room, observation room, as well as debris room, toilet and on-duty office rooms.

Public Space

It is mainly used by patients and their accompanying family members to provide them with services such as formalities and waiting for communication.It mainly includes the entrance of registration fees and emergency hall, pharmacy, building elevator and bathroom and other spaces.

First-Aid Part

It mainly consists of the core departments of emergency —— the disposal room, the emergency room and the operating room. The rescue facilities in the emergency room mainly include mobile X-ray machine, physiological monitor, anesthesia machine, artificial respiration apparatus, defibrillator and pacemaker, etc. The operating room is generally set up separately in the emergency department for emergency rescue. The disposal rooms perform puncture, injection, gastric lavage, enema and catheterization.

Diagnosis and Treatment Part

It consists of two parts: the treatment room and the consulting room, which are used for the treatment of general emergency patients. The treatment includes injection room, infusion room and treatment room. As a basic functional unit, the clinic includes internal medicine, surgery, pediatrics and gynecology, although different hospitals have different specific conditions and different settings.

Under Obsevation Part

Observation room is set up in the emergency department. Patients whose condition does not meet the condition of hospitalization but still need to be observed need to be kept in the

emergency observation room. Critically ill patients who need to be monitored and treated need to go to ICU.

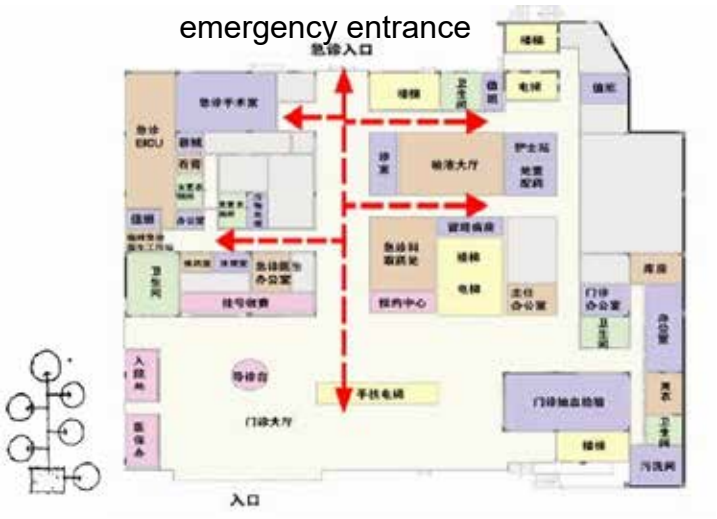
Accessory Part
Mainly has the miscellaneous room, the dirt washes the room and the storeroom, the guard, the duty room and changes clothes, the rest, the office and so on auxiliary sex space.

(2)The spatial layout of the emergency department
After investigation, it is found that there are four main ways to arrange the internal space of the emergency department, which can adapt to the development of modern hospitals and the needs of patients.[34]We analyse two classical and suitable layout for our project.

A)Linear space as the main pattern of spatial organization.[34]
Linear Model:
It has strong guidance and sequence. The corridor is the main passage inside the building, connecting with each emergency department. Considering the waiting space and publicity, the width of the walkway can be appropriately enlarged. The left and right ends of this space can be expanded later and are the predecessors of the branch shape model.

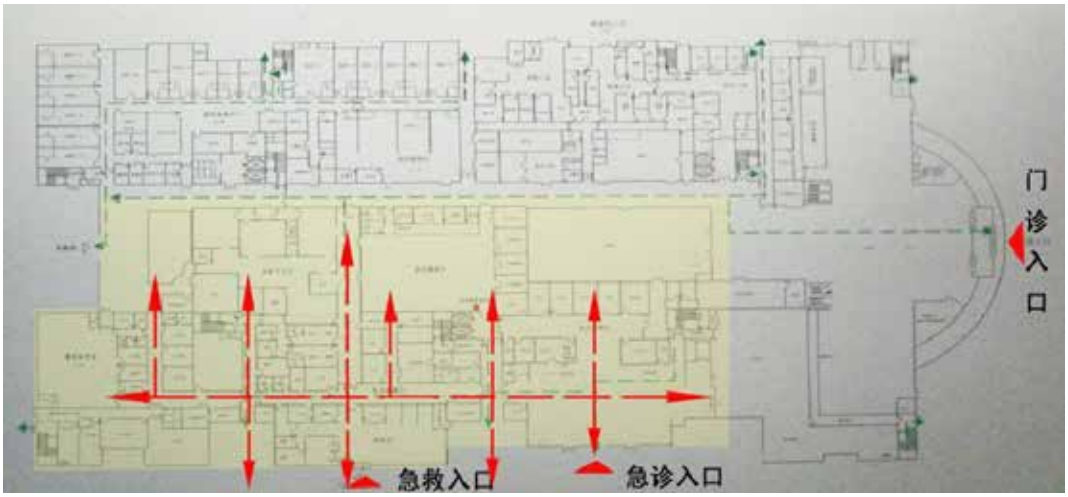
However, with the continuous improvement of emergency service requirements and the strengthening of cooperation among various departments, the deficiency of linear layout mode is gradually exposed, and the improvement of first-aid efficiency lags behind obviously. Medical staff and patients often go to and from each department on both sides of the corridor of the emergency department, which not only reduces the efficiency of medical treatment, but also increases the time for patients to see a doctor. Moreover, the traffic chaos caused by the intersection of people flows also increases the chance of cross-infection.

Branch Shape Model:
Compared with the linear model, the dendritic model is more flexible and can be extended outwards at some nodes, which has the characteristics of sustainable development. In this mode, the main traffic is still the corridor, and each emergency department and waiting room are arranged along both sides of the trunk road, forming a fish-like layout. Each department is arranged in the branch corridor to form an independent area connected to the main road, as shown in the figure below.



Chongqing Xinqiao Hospital for branch shape space[34]

The rooms are connected by "main street" and "alley". The "main street" connects the emergency hall and various departments, while the internal passageway is connected by "alleyways", with alleys and patios arranged on both sides of the street. Each functional department unit is independent, end layout, space organization structure is compact and distinct. This model is widely used and easy to manage,as shown in the figure below.

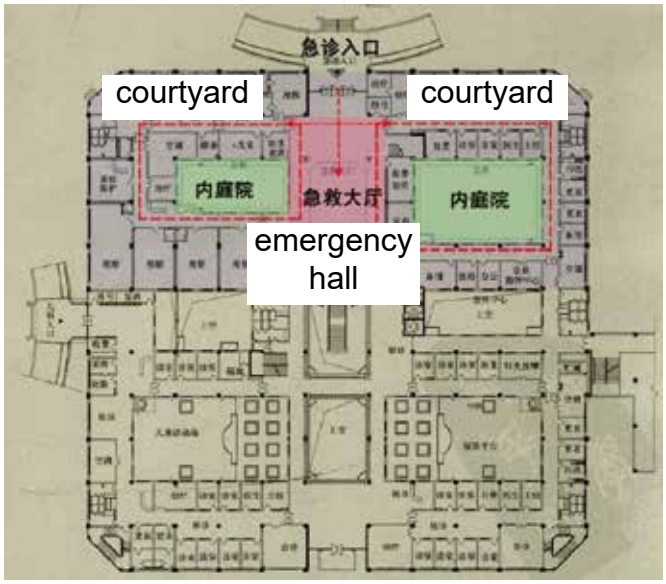


outpatient entrance

emergency entrance emergency entrance

Chongqing Southwest Hospital for branch shape space[34]

B)The spatial organization with the circular gallery as the main composing pattern.[34]
With the improvement of medical level and the continuous enhancement of emergency function, the single linear space can no longer meet the needs of patients, so the circular corridor space is developed on the basis of the branch shape space. The plan of the building is in regular form, with strong spatial adaptability and good integrity. It is composed of inner courtyards, halls and main corridors. The streamline layout often determines the efficiency and development of emergency care. The circular corridor layout can be expanded arbitrarily, and the extension is all around the central courtyard service, and the accessibility of each department is good, easy to contact, very suitable for the development of the emergency department. The model has the advantages of wide vision, good ventilation and lighting conditions, and convenient connections between different departments. The hospital is shown in the picture below. The emergency department of the hospital has a large and a small inner hospital, with traffic flow around the inner hospital. Combined with the first aid hall, all departments of the emergency department are organized together. Patients can reach all departments around the corridor.



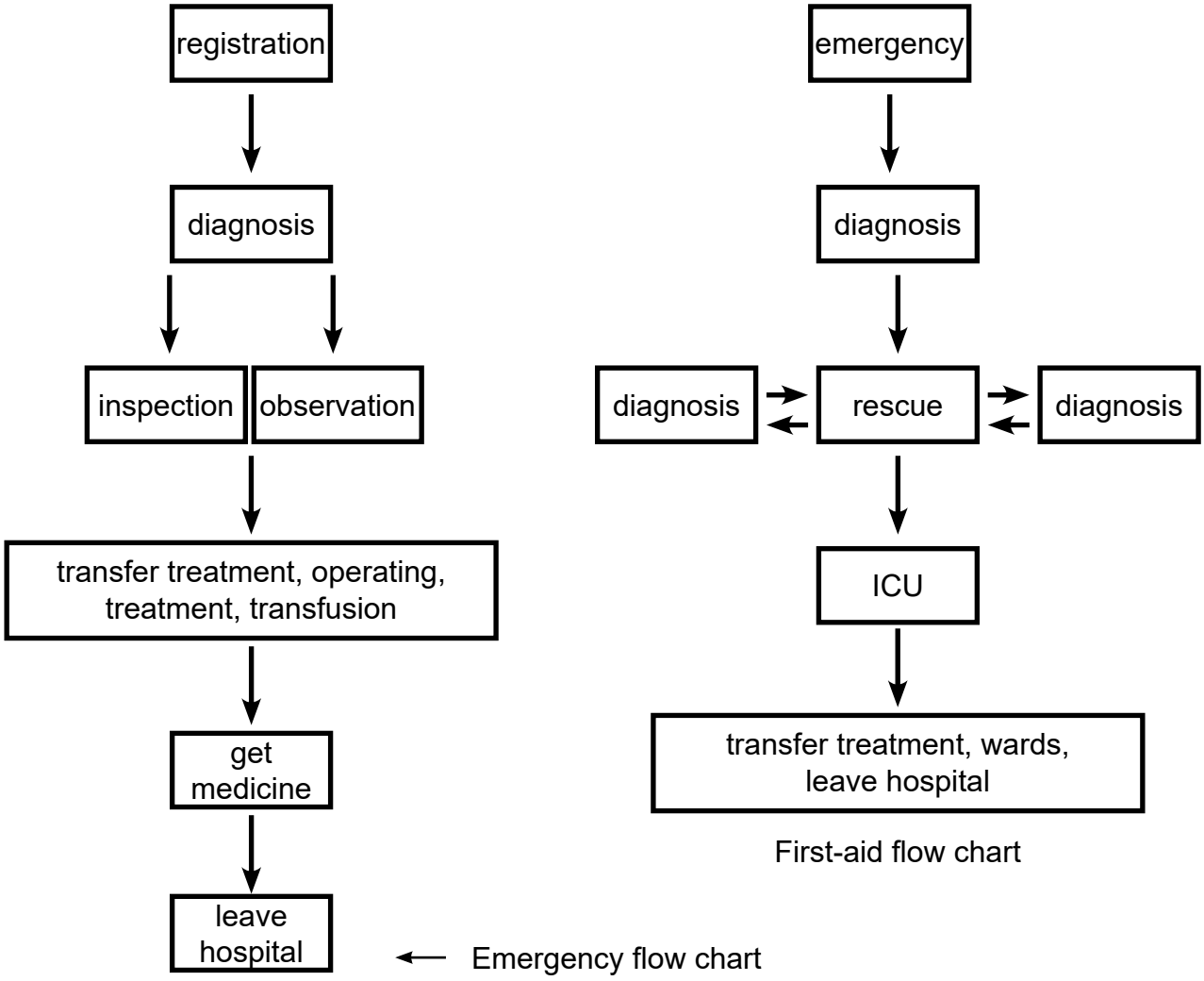
Zhejiang Yiwu Center Hospital for circular gallery space[34]

3.6.2.2 Medical care flow and flow impact

For emergency patients, time is life, and timely diagnosis and rapid rescue should be achieved. Therefore, every process from triage to examination, to rescue, observation and hospitalization should race against time and be efficient. Always highlight the "urgent" word, emphasize the characteristics of time, shorten the treatment time, so that patients get high-speed and efficient rescue treatment. Therefore, reasonable and simple procedures are very important.Process efficiency is the basis for measuring functions. The level of process efficiency will directly affect the management cost, convenience of evacuation, process control and many other problems of hospital buildings.

Emergency departments should have access to ambulance-accessible entrances and exits, and patients often need various examinations, so they should be accessible to medical and surgical departments.

The key to first aid efficiency lies in the effectiveness and timeliness of diagnosis and rescue as well as the convenient and efficient rescue process. At present, many emergency departments of hospitals in the world have adopted the mode of emergency medicine and emergency medical triage, as shown in the figure below.The opening of "green channel" to deal with public health emergencies solves the contradiction of large daily emergency department and emergency first aid, and gives full play to the rapid treatment function of emergency medical treatment. Ordinary daily emergency and emergency first aid should be treated according to different procedures, and the spatial layout should be organized according to the requirements of different procedures.



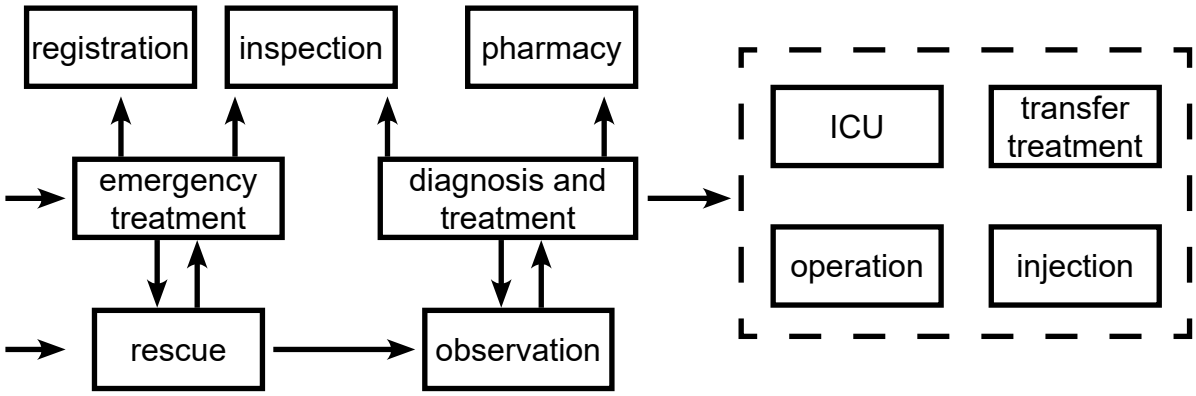
First-aid flow chart

← Emergency flow chart

3.6.2.3 Functional streamline and department linkage

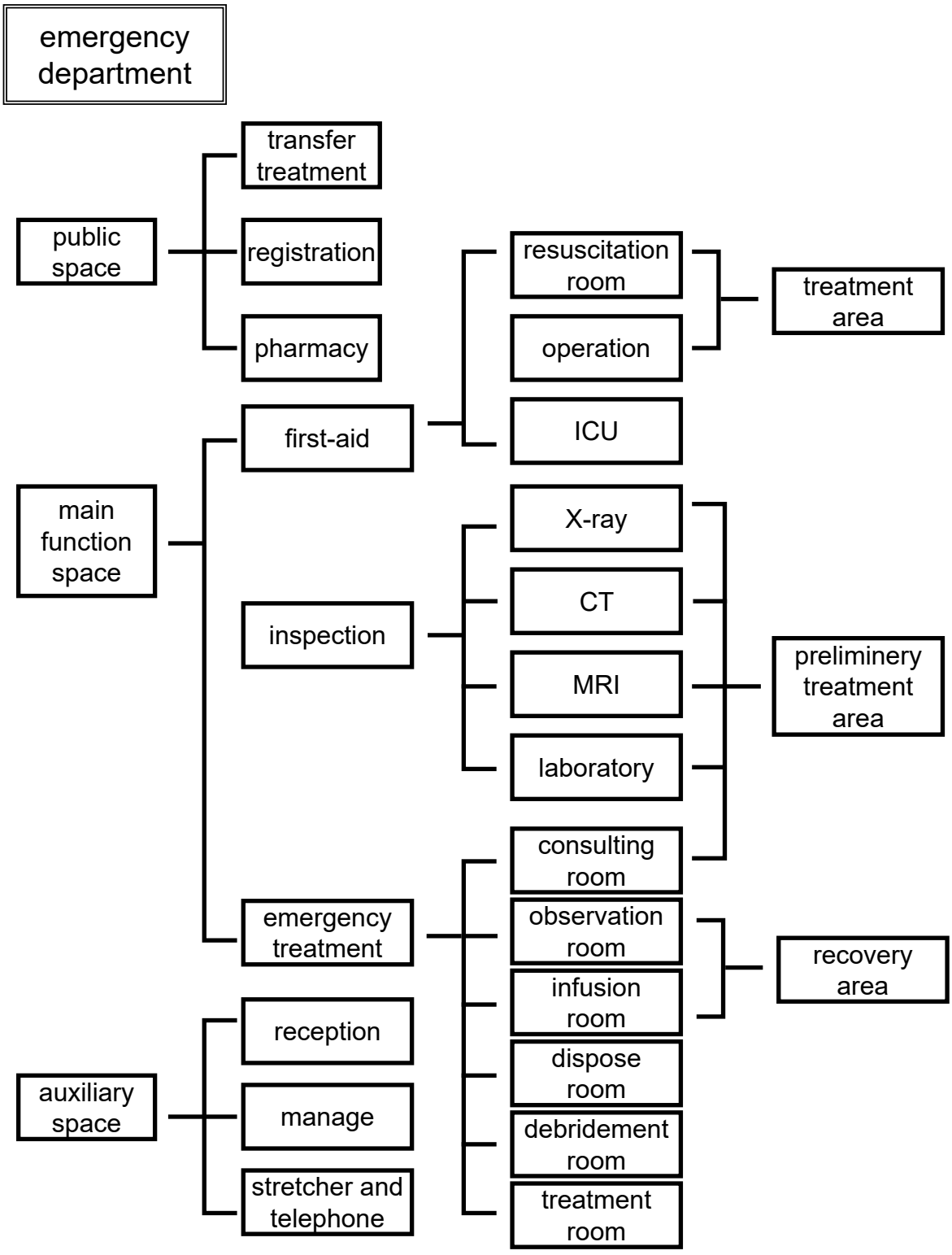
As one of the most important parts of a general hospital, the emergency department has the following main functions:
(1) Provide 24-hour service and deal with emergencies at the same time. It is a place for the treatment of a large number of injured or severely ill patients.
(2) Actively and efficiently treat all kinds of critically ill patients, including the rescue of multi-trauma and emergency patients sent by ambulance and the monitoring and treatment of critically ill patients.
(3) The patients with acute and critical diseases were quickly shunting by minute needles and transferred to each specialized clinic. Therefore, the main function of the emergency department is to identify and diagnose emergency patients;Admission and treatment of emergency patients;Triage and dredge emergency patients.

Users of the emergency department are classified into three categories: patients, accompanying family members and medical staff. The chronic patients of the wounded and wounded are shred to outpatient and specialized hospitals, and most of the acute patients and the injured are the main service objects of the emergency department. There are more severe cases in emergency patients, and the rate of family escorts is much higher than that in outpatient clinics. A considerable number of patients are accompanied by more than one family member. Accompanying family members not only accompany and care patients, but also go through various procedures before and after running. Health care workers are both providers of patients and users of hospitals. After work, they also need a quiet rest environment to relieve the pressure of work.



The emergency composition and streamline

Functionally, the emergency department is divided into diagnosis and treatment area, rescue area and examination area. It can also be divided into primary treatment area -- clinic, clinical examination room (X-ray, CT, MRI, laboratory, etc.), observation room, etc. Treatment area -- operating room, emergency ICU, etc.; recovery treatment area -- observation ward, infusion room, etc., as shown in the figure below. If the symptoms of emergency patients are not easily diagnosed, or do not require hospitalization, but accidents may occur, short-term observation and treatment in the observation room. It is an effective way to deal with a large number of patients with acute illness and illness to adjust the amount and scale of functional space reasonably on the basis of satisfying the basic functional settings.



The emergency functional partition

In the process of organizing functional streamlines, the reasonable and smooth flow of traffic is the prerequisite to ensure the smooth use of various functions inside the building.

-Effects of functional layout on emergency department efficiency
Medical building is a type of building mainly based on function, which embodies strong functionality. Due to the increasingly detailed division of labor in the emergency department of modern hospitals and the increasing number of supporting departments, it is the premise of reasonable and coordinated functions of each department and department to deal with the functional streamline relationship, which is closely related to the functional efficiency.

(1) The flow of people is decomposed according to the functional composition. Each functional department has an independent traffic flow line, which will not interfere with each other.

(2) Arrange each functional space and department according to the treatment process of the emergency department of the hospital, organize traffic routes, and prevent the flow of people from crossing routes and detour.

(3) There should be sufficient emergency observation beds in the emergency department, and the emergency ICU department should be considered. Observe is very important function to use a room.

-The effect of streamlining on emergency department efficiency
Passageways and staircases with large population mobility should adapt to the flow of people and distribute relatively evenly, so as to effectively divert people and maximize the efficiency of medical treatment.

(1) Classification of patients
Patients were classified according to the acute and critical condition of the disease:
a. Serious patients, those who need immediate rescue or who are in danger of life at any time;
b. Critical patients, whose vital signs are not stable enough and need to be kept in hospital for further observation and monitoring;
c. Patients with general emergency, who can leave the hospital without rescue or surgery but can buy medicine after treatment.
The treatment process of patients with different diseases is different and the diagnosis and treatment process is also different. Severe patients, to rescue after registration. Patients at risk are given priority over other patients to ensure that vital signs are stable. General emergency patients were triaged by nurses to various departments for medical treatment.

(2) Characteristics of the visiting population
Patients who come to the emergency department are in an emergency or critical condition, so each patient is accompanied by about one to three family members. A large number of patients, their caregivers, and medical staff are gathered inside the emergency department, creating a mixed situation. Patients with different conditions, various diseases, mutual easy to cause cross infection. Therefore, effective organization and distribution of people is the main measure to avoid the high concentration of a large number of people.

(3) Dividing flow within the emergency department
Reasonable arrangement of entrance and exit is the first step to organize emergency

abortion. The patient of different kind is separated appropriately, in order to achieve the purpose of health isolation, and also can disperse the stream of people.

a. Hall shunt (core shunt) -- patients from each department enter the waiting room of each department through triage shunt in the emergency hall.Separate patients with different conditions and different departments at the triage table in the emergency hall. The emergency hall serves as the core to contact the consultation rooms. The other consultation rooms constitute radiological functional units, which are arranged centrally but separated from each other. It is convenient to manage and will not cause cross-infection. This shunt mode emphasizes concentration, that is, traffic streamline, spatial organization is simple and easy to find, unobstructed line of sight, easy to timely rescue patients.

b.Separation of waiting rooms -- patients are transferred to different consultation rooms through waiting rooms to ensure an orderly process.

c.Walkway flow division - using a linear plan flow organization.Just as in a town plan there is a main thoroughpass, so in the emergency department there is a main walkway. Through this corridor, the emergency, first aid and medical technology departments of the hospital can be linked together, and the functional departments of the emergency department and the shared hall of the emergency department can be organically linked. On the corridor, the positions of each department can be clear at a glance, so that patients can find the department to go to in the shortest time.

(5) Diversion of clean and dirty
According to the medical and health requirements of the organization of the flow of people route, distinguish between the contaminated area, clean area, or bacteria area and aseptic area, to prevent mutual infection cross. Some departments with clean requirements, such as operating room, ICU, etc., should follow the principle of cleaning and diversion design, to ensure the safety of patients.

3.6.2.4 Plan and vertical traffic organization

In a general hospital, the department with the most complicated streamline, the highest work intensity and the highest frequency of use is the emergency department. As can be seen from the previous "first aid flow chart", the emergency room is closely linked with operating room, intensive care unit (ICU) and inpatient ward in the emergency process, and the time requirement is relatively high. Therefore, the most important thing is to design a good flow of people, logistics transportation organization, planning and improve emergency facilities.

Transportation system is to organize the main functional space of the building and connect them together, so that people or things can flow and the building can be used normally space. It is divided into internal traffic and external traffic. The internal transportation organization connects the functional spaces within the building, mainly for patients and their accompanying families, including the transportation hub, horizontal transportation and vertical transportation. The traffic organization uses each horizontal flow line and the hub to form the space and the node on the plane, and then uses the vertical traffic such as the building and the elevator to form the three-dimensional network of the three-dimensional space. A variety of emergency and first aid function spaces, ancillary rooms and transportation organizations are combined to form the internal space of the emergency department. Hospital emergency department patients more, also the accompanying

family members, emergency, so the general layout and form in the side of the outpatient department of independent area, in the building register and set up a triage, take medicine

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The smooth horizontal and vertical traffic in the emergency department is directly related to the successful rescue of patients, so the traffic space is the most closely related factor to the efficiency of medical treatment. The traffic organization of the emergency department is the overall framework of horizontal and vertical traffic, which can be divided into the following two modes:

-The organization pattern of horizontal traffic space
Horizontal traffic space includes vestibule, lobby, corridor, shared space, etc. In the horizontal traffic space, the patient's behavior is fluid and the residence time is short. If the departments with close internal functions are arranged next to each other, the streamline distribution will be more reasonable. However, the horizontal traffic may reduce the efficiency because the traffic streamline is too long.The horizontal organization pattern can refer to the 3.2.1 character--spatial organization pattern about "internal space composition pattern of emergency department".

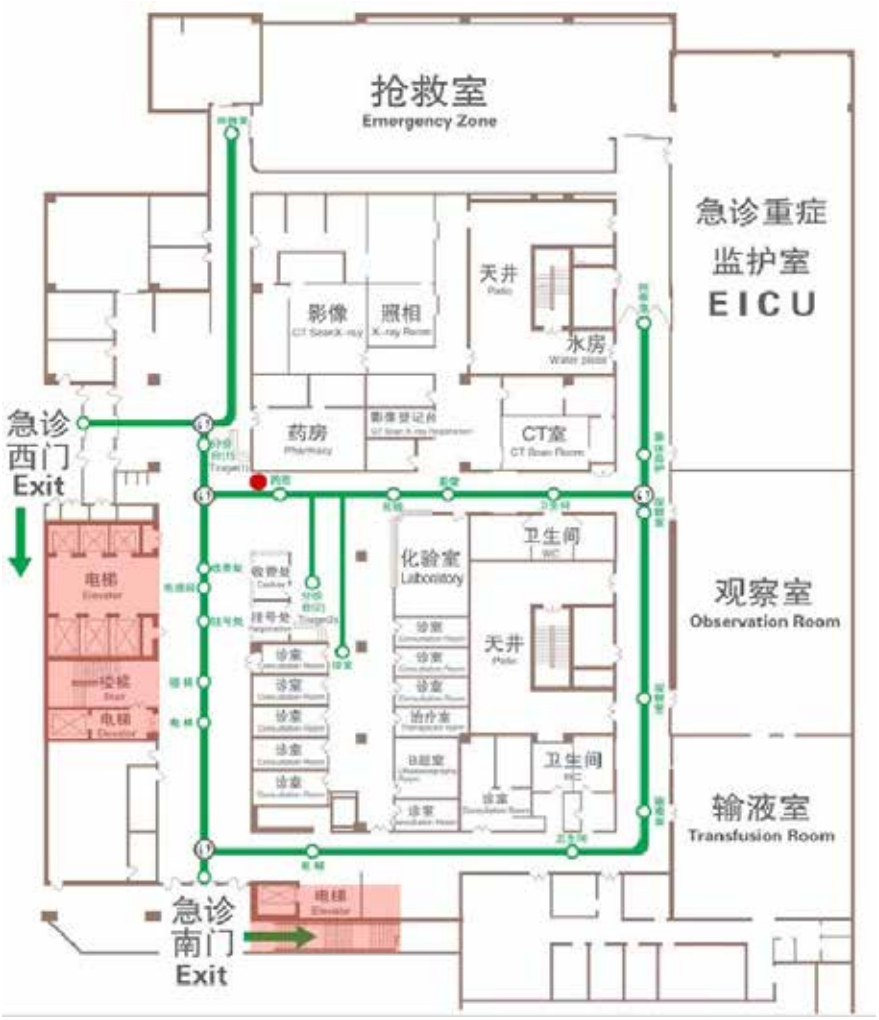
-The organization pattern of vertical traffic space
The emergency department is generally located on the ground floor, but some hospitals will place the intensive care unit, observation department and other departments on the second floor due to the terrain or size, and some operating rooms are set on the higher

floor. The main vertical traffic organization mode most commonly used in large emergency departments today is the combination of stairs and elevators. Elevator hall is generally arranged in the place connected with the hall. When the emergency floor is above the medical department and the inpatient department, the elevator can also be used as the vertical traffic for medical technology or hospitalization.

It can be seen from the observation of the medical treatment process of ordinary emergency patients that the characteristics of patient flow are concentrated and dispersed, and then concentrated again, or concentrated after multiple dispersions. Therefore, it is the focus of transportation organization to deal with the connection between the main functional departments and other functional spaces. The elevator is mainly used to transport patients who cannot take care of themselves on the push bed and patients and their families who go to other floor departments. The stairs are used for the evacuation of people and have an auxiliary function. In addition to ensuring the smooth passage in the room, special elevator for surgery and emergency elevator must be set up to make the emergency patients, medical personnel and medicine materials arrive in time.

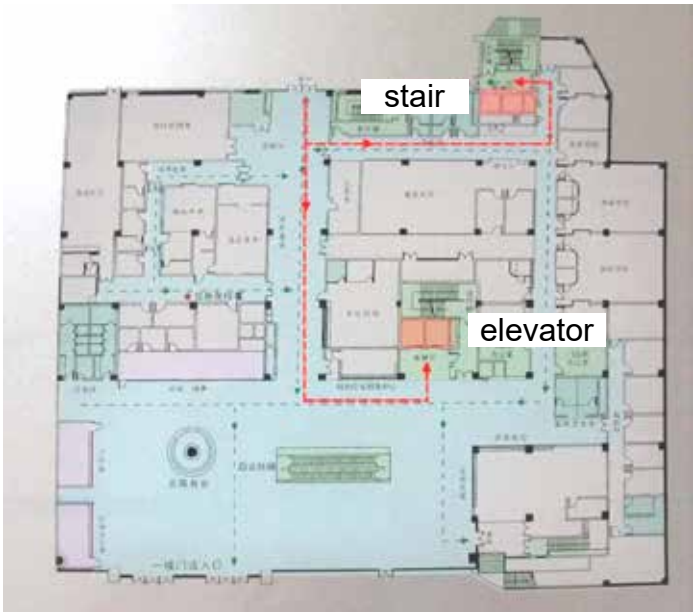
(1) Stairs
Inside the emergency department is the primary vehicle for vertical communication. To ensure traffic line short swift smooth, the position of stair should be clear easy to look for. Most emergency department staircases are set inside the emergency hall, patients can see the staircases as soon as they enter the hallway, and then are diverted to the functional departments through the staircases according to their own needs. Because this often is in the most conspicuous, the crowd is the most, the position that the line of sight is the most smooth design main stair, want to prevent stair entrance and other stream of people more department to be apart from distance is too short and cause jam, not convenient use phenomenon. Besides, should enlarge the space of the entrance and exit of stair, have certain buffer space, and set to be combined with streamline each other on linear passage.

(2) Elevators
Arrange elevator to want to be used in order to go to the convenience of the patient and marked good look for a principle, in each functional space can use the shortest distance and time to arrive. Most of them are arranged near entrances and exits or horizontal traffic hubs, while others are arranged near emergency hall, emergency treatment area or observation area, so as to have convenient contact with operating room, inpatient department, ward, etc. The vertical traffic of Beijing Chaoyang Hospital, as shown in the figure below, is a successful organization of multi-directional traffic flow.[34] Emergency vehicles drive directly from the ramp to the first-aid entrance of the ground floor, and emergency pedestrians descend to the ground floor by stairs or elevators.



Beijing Chaoyang Hospital vertical traffic position[34]

When the patient sees a doctor, the action is inconvenient, the mood is unstable, the mood is impatient, so the vertical traffic must be clear and easy to find, in order to prevent the delay of the disease. For example, the elevator of Chongqing Xinqiao Hospital is far away from the main entrance, concealed, long and tortuous streamline, poor sight, and extremely inconvenient for patients to find, as shown in the figure below. [34]



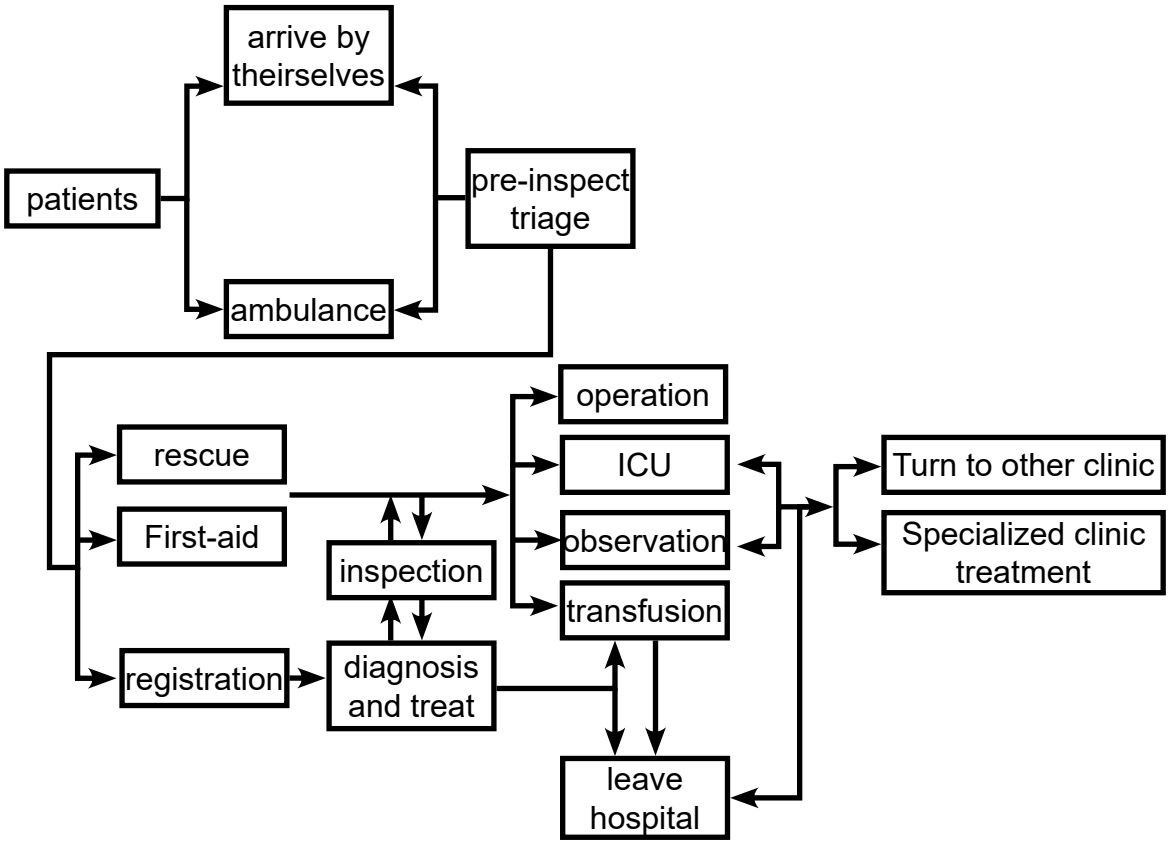
Xinqiao Hospital of Chongqing elevator locations[34]

The vertical traffic set in the emergency department, namely the elevator, should be based on the principle that patients can be treated immediately when they are lifted out of the ambulance, so that patients can reach the consulting room or emergency room or operating room in the shortest time and distance, so as to reduce the anxiety of patients and their families.In the case of emergency, the patient can be rescued directly as soon as he enters the elevator, giving full play to the emergency features of the emergency department.

In summary, the following requirements must be met in the organization of traffic space within the emergency department:
Avoid cross - infection: doctor - patient shunt, clean sewage separation.

Convenient, orderly and efficient: on the basis of short and orderly streamline, improve the traffic efficiency as far as possible, avoid streamline chaos and interference.

Clear location: the transportation space system is simple and clear, the signs are obvious, and it is highly identifiable.



The emergency basic business flow chart

3.6.3 The difference and contrast between outpatient and emergency

There are great differences between the outpatient department and the emergency department, and their architectural design characteristics are not the same, so they cannot be replaced by each other. Now, the differences between the outpatient department and the emergency department are compared in the following table.

differences	outpatient department
Main characteristics	Each department patient's condition is common, the patient can return on the same day, leave lag time is short
People flow characteristics	The flow of people is large and complex, and the peak time is concentrated in the morning
disease characteristics	It does not require immediate treatment and can be delayed
Time requirements	Short not urgent, open during working hours
Department set up	Internal medicine, surgery, obstetrics and gynecology, pediatrics and other clinical departments
Different process	All patients use the same process: registration -- waiting for treatment by department -- seeing a doctor -- examination -- taking medicine
Waiting time	All patients need to wait for a registration
Plan layout and vertical distribution	More departments, multi-layer layout

The differences between the outpatient and emergendy department

3.7 Analysis of the characteristics of architectural elements on the ward areas

In this chapter, the factors that influence the design of inpatient wards are analyzed firstly, and the ward design strategies of modular large general hospitals are proposed.

3.7.1 The limitation of interior space scale

In the inpatient ward, the patient receives treatment and lives here, the escort needs to take care of the patient and needs a certain space to rest, and the medical staff needs to complete the related medical care work in the ward. Therefore, the scale of the wards should be designed to take into account the activity needs of different groups of people in different situations. Although the larger size of the ward can well meet the related activities of different groups of people, blindly seeking larger size will only lead to the waste of space resources and the increase of construction cost; on the other hand, smaller is not always better. Because the size design is too small, the room will be crowded, and the furniture can not be placed normally, affecting the related activities of ward users. Therefore, it is necessary to study the indoor space scale of the ward and put forward a reasonable reference standard.

The interior space scale includes furniture and equipment size, human activity space scale and human perception space (psychological scale) scale. The spatial scale of furniture and equipment is the size of commonly used indoor furniture and related equipment. The spatial scale of human activity refers to the spatial scale needed to meet the needs of human behavior, which is generally considered according to the dynamic scale of human body and the scope of behavioral activities. The scale of psychological space (perceptual space) means that the scale of indoor space must not only be designed according to the dynamic range (physical space) of people's indoor activities, but also must consider the psychological feeling of people in some spaces. For example, if the indoor height is too low, it will produce a sense of oppression.

-Dimensions of related medical equipment and furniture
Furniture and medical equipment are an essential part of the indoor space of a hospital. In the inpatient ward, people's behavior and activities also revolve around these items. Different types of furniture and medical equipment have different dimensions and functional characteristics, but they are all designed based on the basic human scale. There are many manufacturers in China that produce and supply medical furniture and equipment. There are different specifications of furniture and equipment for hospitals to choose freely. Because be in hospital ward space is limited, to put aside more space will be used flexibly, the furniture with simple, practical style can be chosen normally inside ward. It will be helpful to study the interior space scale of the ward to know the size of the commonly used furniture and medical equipment. The sizes of medical equipment and furniture commonly used in the ward are shown in the table below.

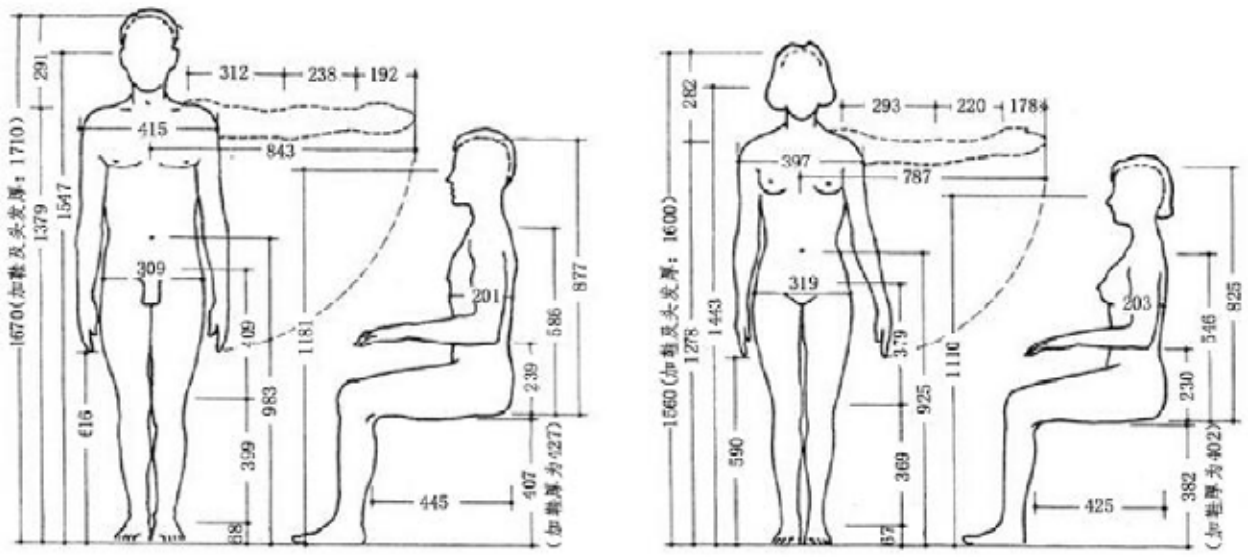
category	name	length(mm)	wide(mm)	remark
medical instrument	wheelchair	1100	650	manual wheelchair
	medical trolley	690	440	
	patient rounds cart	530	450	
furniture	sickbed	2000	900	height adjustable
	night table	480	480	
	escort chair	1900	620	development size
		800	620	folding size
	cabinet	850	400	Most of them are embedded, and the specific size is determined according to the design requirements
sanitary fittings	toilet bowl	700	450	
	wash basin	750	500	
	shower	900	900	size of space required

The size of frequently-used medical equipment,furnitures and sanitary fittings in the wards

-Spatial scale of human activity in the ward

(1) Basic body size

The basic physiological dimensions of human beings determine the spatial scales of their corresponding activities[4]. As shown in figure below, the basic dimensions of adult male and female human bodies in China are higher in most aspects than that of adult female. Therefore, appropriate reference values should be selected according to the specific situation when considering the spatial scale. For example, when designing the height of the door, in order to ensure that most people can pass, the height of the man should be selected as a reference; and when be opposite similar to the design of mural ark, to be able to let most person can stretch one's hand to reach, appropriate chooses female body size to serve as reference. Since human activity is a dynamic process, in addition to the basic human size, the dynamic size of human body also plays an important role in determining the scale of activity space. In the design, you can refer to the relevant design materials or manuals.



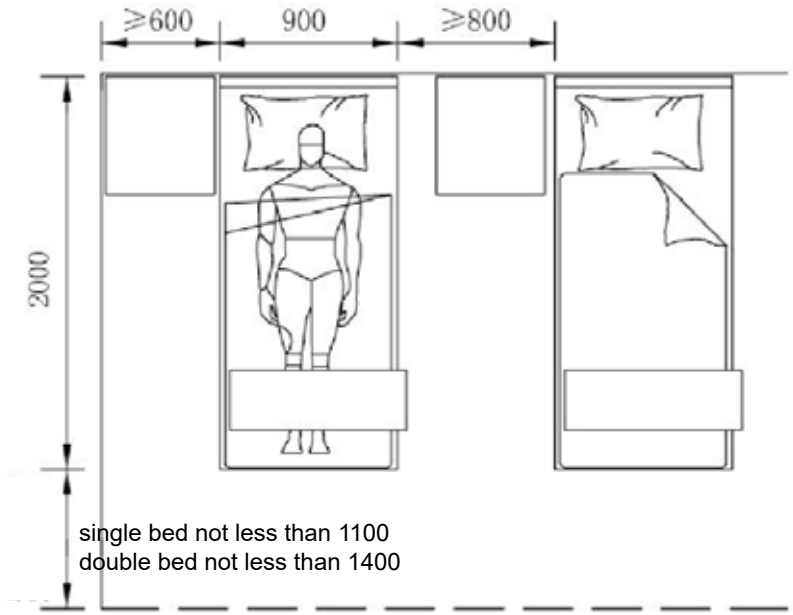
The basic body size of Chinese adult male and female

(2) The passage width

Passing width is the most basic human activity scale in the ward, which is mainly affected by the shoulder width and chest thickness of the human body. Referring to the above figure, the shoulder width of adult men is 415mm, and the chest thickness of adult women is 203mm. Taking into account the influence of wearing clothes and the safety and comfort of passage during the passage process, the basic passage width required by a person is usually 600mm for the front passage and 300mm for the side passage. This is the most basic traffic width. [4] However, in the inpatient ward, different users need different traffic width due to their different physical conditions and traffic modes. Therefore, specific considerations should be taken into account for different situations.

(3) Ward unit

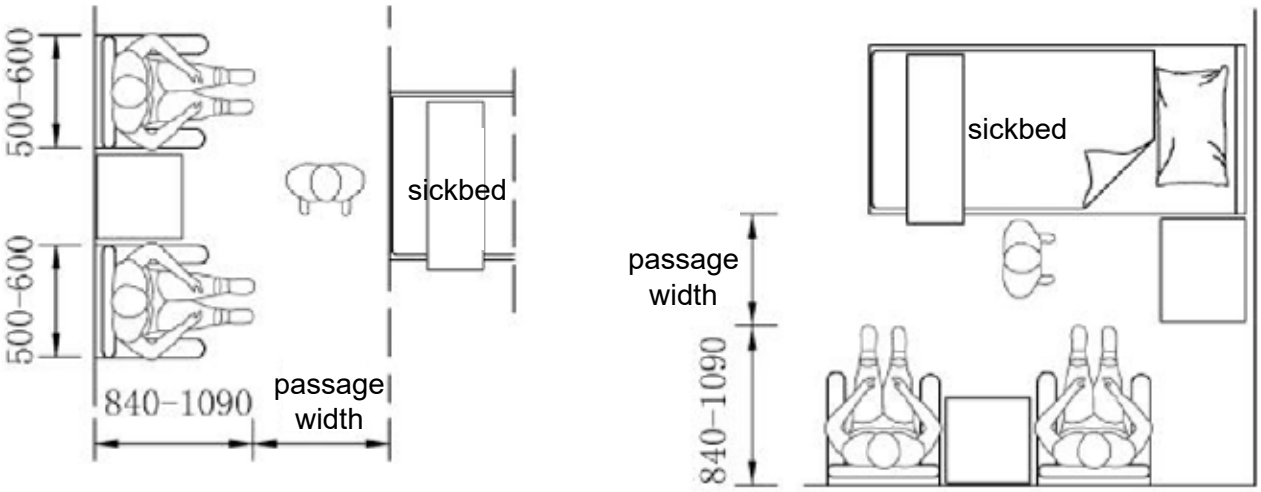
The sickbed and its surrounding space is the main area for patients to receive treatment, care and daily life, and is the core part of the ward. The bed unit needs to provide a certain movement space for patients, provide space for placing personal belongings, and meet the requirements of nursing staff and equipment placement. China's general hospital architecture design specification stated in the parallel sickbed spacing is not less than 800 mm, the bed against the wall and wall spacing shall not be less than 600 mm, the single bed in the channel is not less than 1100 mm, double bed, the channel is not less than 1400 mm (see below), this is the room available for reference in the design of the smallest scale standard, but the week space scale is suitable for the actual use of bed and no reference value. [35]



The dimensional requirement of the space near the sickbed[35]

(4) Rest and reception space

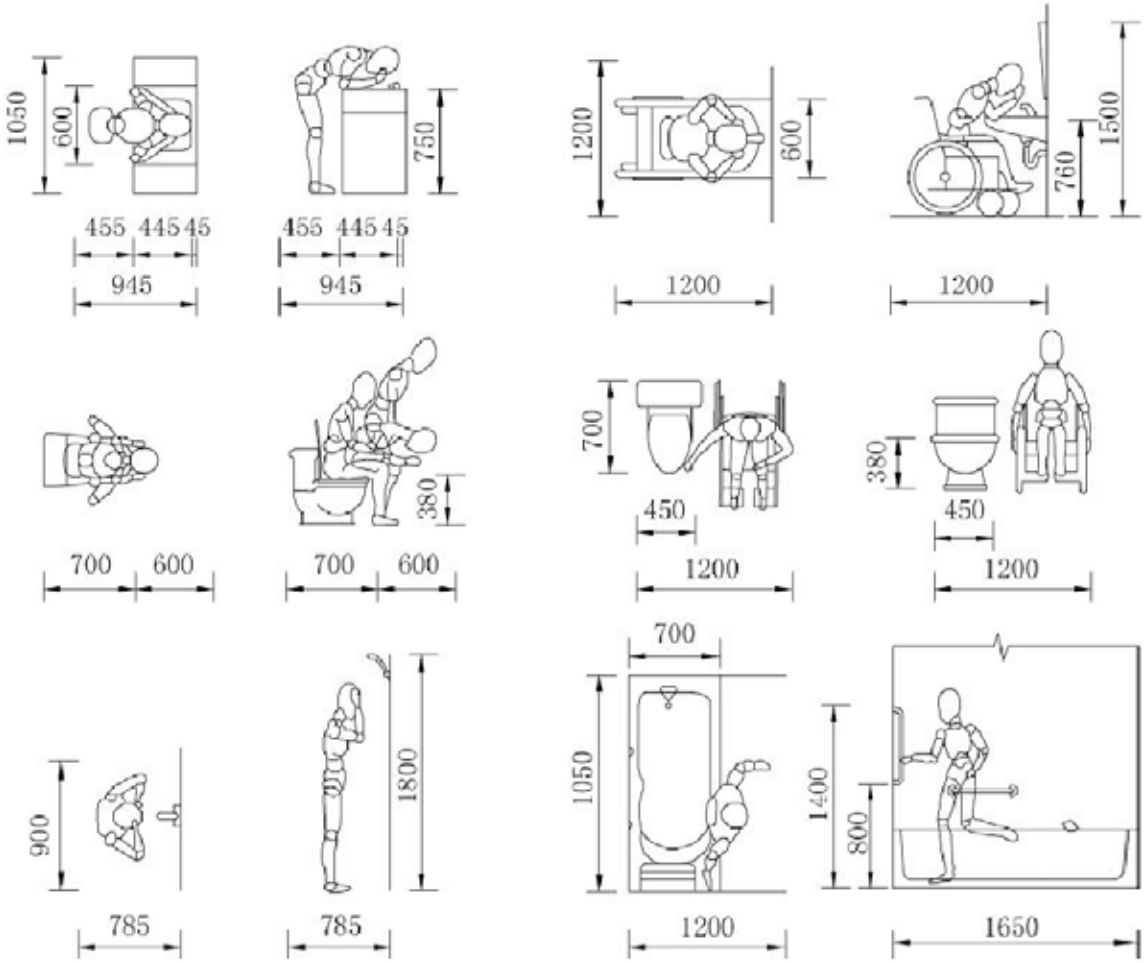
Inpatients are often accompanied by family members and relatives to visit, so it is very necessary to set up a certain rest and reception space in the ward.Due to the limited space, the current ward mainly by providing folding beds, chairs and other furniture to solve this demand.The rest space is usually set by the end of the bed to the wall or the side of the innermost bed, so the influence of the rest space on the aisle space and the bed space should be paid attention to in the relevant size design (see the figure below for details)[35]. As shown in the figure, the size of the seating area should be considered for the basic seating area. When the sofa is arranged, the space required for the combined furniture will be larger.



The essential spatial scale of space near the sickbed[35]

(5) Toilet

Toilet is an important functional space in the ward, mainly to meet the basic needs of patients, such as toilet, bath.Today's wards are designed with a separate bathroom in each ward to facilitate the use of patients.Toilet interior decorate basically around wash bath, be like toilet, wash gargle 3 main activities spread out.Although the area is relatively small, the rationality of its internal layout affects the use of patients and their families, so it is very important.The factor that influences toilet dimension design and space to use basically is the person to be in among them relevant behavior and measure (see details below for details) and clean provide dimension, decorate means and requirement. [35]

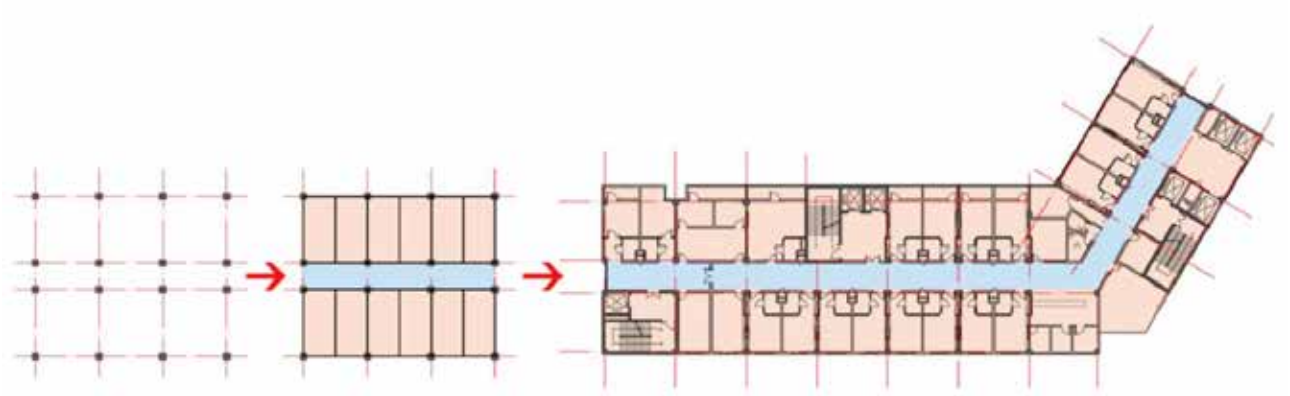


People’s activities in the toilets and relevant dimension[35]

3.7.2 Design strategy of inpatient ward in large general hospital

3.7.2.1 Adaptability of plan layout

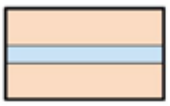
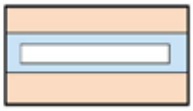
As shown in the figure below, it is often used in the layout of nursing units in many ward buildings. A simple and regular unit plane can be obtained by dividing a column grid unit into two wards for repeated arrangement. Most of the nursing units investigated by the author have adopted this method, and the nursing unit models formed are mainly single corridor and double corridor. However, in different construction projects, site conditions, construction funds, technical conditions, modeling requirements are different, and a single plane form lacks richness and flexibility to adapt to different needs. Therefore, in the design of nursing unit and ward plane form, different forms should be used according to the specific situation. [35]

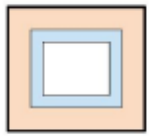
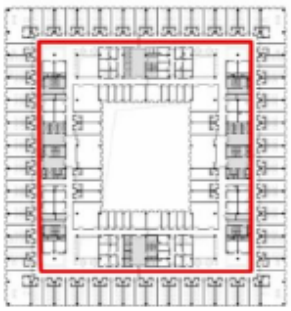
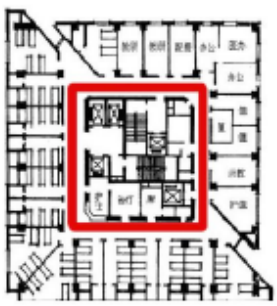
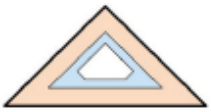
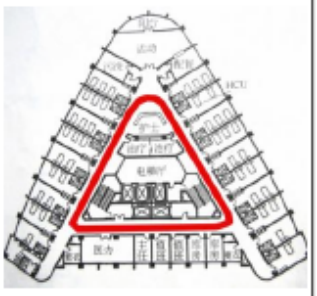
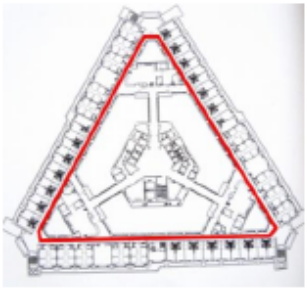
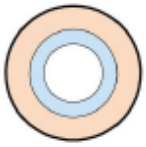
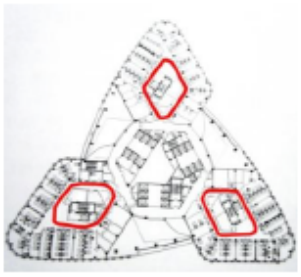
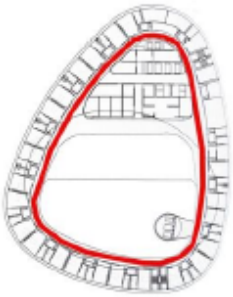
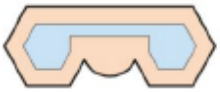
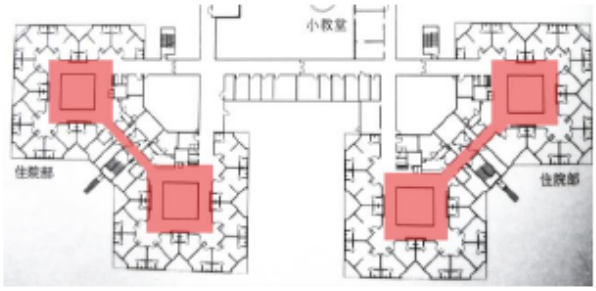


The common arrangement form of the nursing unit[4]

-Plan form of nursing unit

The plan forms of nursing units are divided into four types: single gallery, double gallery, ring gallery and ring enclosure.[4] For some nursing units, such as the semi-compound corridor type formed by the combination of single corridor and compound corridor, and the polygonal unit form formed by the combination of single corridor and circular enclosure type, the author thinks that they are all combined and derived on the basis of these four types, so there is no separate classification.

typo-logy	plan diagram	examples		remark
single passage		 Shanghai Huashan Hospital	 Chongqing Daping Hospital	Nursing unit is one of the common forms, the structure is simple and neat, relatively economic.
double passage		 Chongqing Peiling Hospital	 Beijing Plastic Surgery Hospital	A common form of nursing unit that can be arranged in both directions compared to a single gallery.

Ring passage				The form is simple and the column net is very regular.All directions can be fully used for lighting.
	square ring corridor	Nanjing Drum-tower Hospital	Shanghai Shuguang Hospital	
				Can use each direction daylighting, but triangle plane is easy to produce the corner space that goes against the use.
	traiangle corridor	Chongqing Wushan Medical Center	Tokyo Near-sea Hospital	
				The circular corridor with polygonal curves makes the facade more fluid and free, which can adapt to different site boundary restrictions.
	circle or polygon corridor	Panjin Center Hospiatl	Suan Carlos King Hospital	
Circular enclose passage				This form can not only use the directional lighting, but also greatly shorten the nursing distance.
		Agatarid Hospiatl in Germany		

The different layouts of the nursing unit[35]

The single corridor type and double corridor type in the table are the more used forms of nursing units in China. Its advantage lies in the simple and neat structure form, but when the number of wards is more, the corridor will be too long for nursing, and it increases the building shape coefficient, and too long building facade is not conducive to the facade modeling processing of the building. Corridor type can be divided into square, triangle, circle and polygonal corridor according to the different plane shapes. Among them, the square ring corridor type is conducive to the regular layout of the column network, which is more suitable for the residential buildings that need to set more underground parking

spaces, but it will also make the architectural form relatively simple and regular, slightly rigid.In contrast, triangle, circular and polygonal corridor are more prominent in shape, but triangle corridor plane is easy to produce adverse corner space, while circular and polygonal corridor is more flexible, can better adapt to different site boundaries, to create a free and smooth building outside surface. Ring around the jewels is existent and ring is relatively similar type, can make full use of the anisotropy of daylighting, difference lies in the ring around the jewels in the traditional sense of the linear aisle space aggregation has become a point of space, if the nurse station layout in this point space, the distance of the medical staff to every room is basically equal, effectively shortening the distance between nursing.

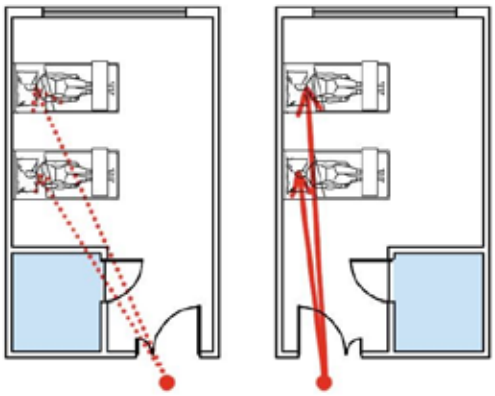
It can be seen from the above that different forms of nursing units have different characteristics. In the actual project design, the appropriate plan form of nursing units should be selected according to the specific requirements, and certain changes and combinations should be made according to the needs.For example, with the continuous expansion of the scale of the current hospital and the emergence of multi-type wards, the traditional ward units of large departments are divided into a number of specialized disease units.

-Toilet

In the early nursing unit, the toilet is set centrally, which brings a lot of inconvenience to the patients.In present in hospital ward, has equipped independent toilet, its put position can be divided into inside, middle and outside 3 kinds. Different placement positions have different effects on patient use, nurse observation, room lighting and so on.

(1) Inside - on the corridor side layout[35]

When toilet relies corridor to decorate, its position can be located in sickbed right lower part or oblique to the direction. Through the comparison and analysis of the two positions, when the toilet is located at the bottom of the observation of obstructed vision, and by the oblique direction of the arrangement of nursing staff can directly observe the whole situation of the two patients. The mixed area formed near the entrance of the ward door when placed in the diagonal direction provides greater operating space for the nursing staff compared to the one placed directly below, effectively utilizing the corridor space. Visible, when the toilet relies on corridor side to decorate, its position appropriate depends on sickbed inclined to decorate the direction (see details below).

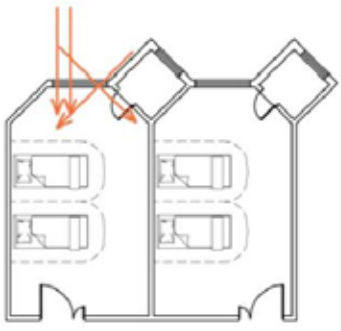
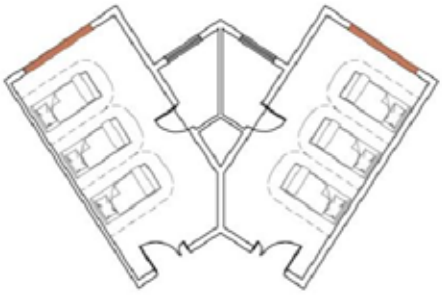
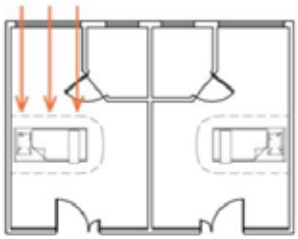


The contrastive analysis of different toilet location[35]

-Outside - on the exterior wall layout[35]

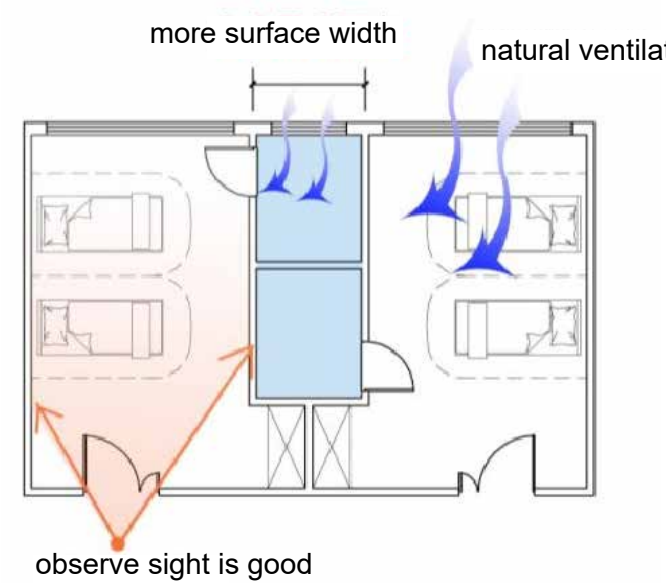
The toilet is set by the corridor in the same way as the hotel room, but in actual use, the characteristics of the hospital makes the ward can not be considered purely from the perspective of living, and the first priority should be the treatment and nursing of the patient, so in some ward design at home and abroad, there is the "external wall toilet mode". Relying on the external wall layout can make the toilet get good natural ventilation and lighting, reduce the air pollution to the ward, and will not block the line of sight observation of the medical staff caused by the influence, some studies show that the same layout of the toilet outside than the built-in can improve about 15% of the nursing efficiency. But on the contrary, because the setting by the external wall will occupy part of the outer wall space that can be used for window lighting, it will have a certain impact on the lighting of the ward.In addition, as the location is further outward, the corresponding pipeline length will be increased.

According to our survey observation, compared with single and double rooms, multi-bedroom and three-bedroom rooms are usually larger, deeper and have a higher demand for light. Therefore the author "Kuang Yi" thinks, below the circumstance that produces keep out to daylighting surface when toilet outside buy, 3 people and above many people in unsuitable use this kind of decorate means. To room area and depth can be designed relatively smaller single room and double room character, if be opposite to observation and visibility degree requirement is taller, can consider to toilet relies on external wall to decorate. At the same time, the lighting problem caused by this can be improved in the following table. One kind is to have toilet metope inclined processing, make it and exterior metope form obtuse angle in order to facilitate the light to enter a room. Another way is to use the corner space between adjacent rooms to arrange the toilet in the nursing unit of the circular layout, thus greatly reducing the impact on the lighting of the ward. As a result of having no effect to room daylighting almost in means of this kind of layout, even if be in 3 people and above in many people also appropriate use. Larger double room or single room in room measure, can decorate bed in a side of open window face, let a patient can contact natural light.

Way 1: slope the toilet	Way 2: use the angle space	Way 3: change the sickbed position
		
The toilet wall is tilted so that more light can enter the ward.	Use included Angle space to decorate toilet, make full use of space to also avoid the lighting effect to ward already, can obtain the largest lighting area.	When the room size is generous, the bed is placed by the lighting side, so that the patient can be closer to the lighting window.

The way to improve lighting on outside toilet[35]

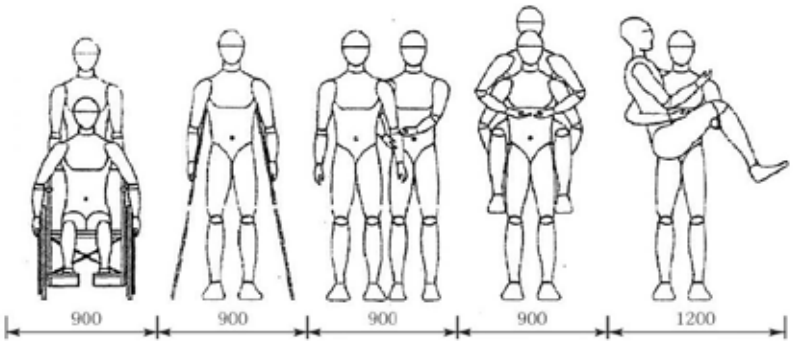
(3) middle - arranged between two wards[35]
Because the external toilet is easy to affect the lighting of the ward, so in some ward designs, the toilet is placed between two wards, so that both the toilet and ward can get better natural lighting and ventilation. This arrangement of the toilet will not affect the window opening of the ward and the observation of patients by medical staff, and the pipeline can also be centralized arrangement (as shown below). But the main drawback is that it will occupy the width of the building of the nursing unit of the ward building, so the number of wards can be arranged on the same length of the lighting surface will be reduced.In the design of ward building, many hospitals have compact business rooms and limited construction land, so it is often necessary to arrange wards in a wide direction with better lighting as much as possible. Accordingly, look at present, this kind of opposite wide request more toilet decorate a way to still not quite apply to the ward design of domestic hospital.



Toilet set in the middle[35]

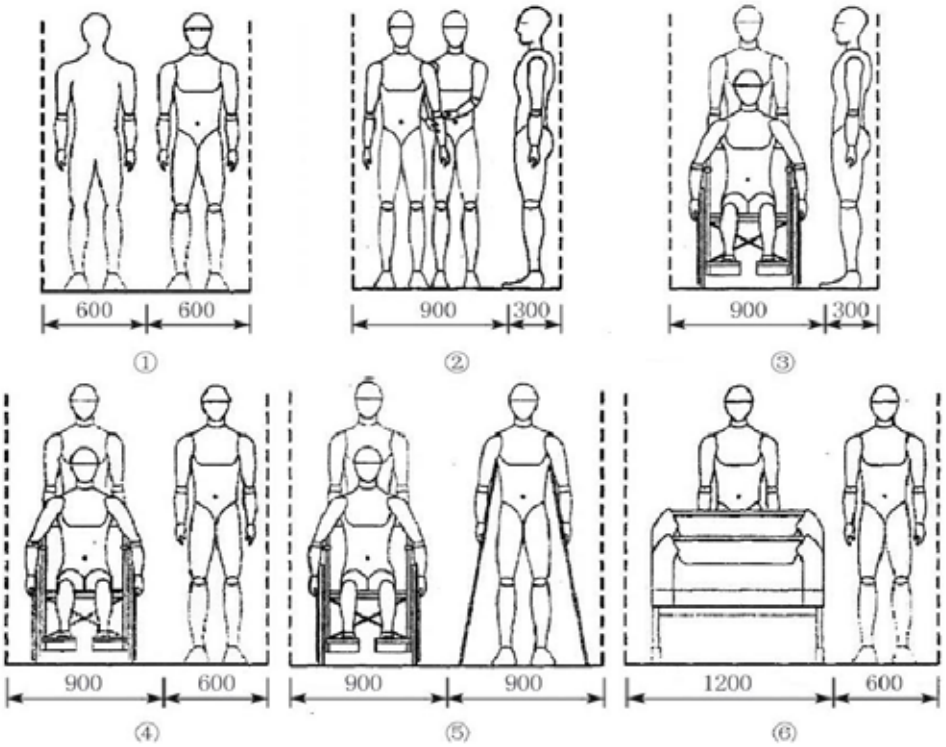
3.7.2.2 Spatial scale adaptability

-Size of door and window
(1) Size of door
The width of the door in the ward mainly includes the width of the ward door and the bathroom door, and its size should be set according to the corresponding behavioral scale of users to meet their current needs. According to the previous analysis, the basic traffic width of normal people is 600mm for the front traffic and 300mm for the side traffic. But patients in the ward because of different physical health conditions, the way is often different from ordinary people. For example, some patients need to use crutches, wheelchairs and other tools to move, while some patients need the help of others to move, so the required passage widths are different, as shown in the figure below.



The transit width of patient in different situations

Patients, family members and medical staff are often in the ward at the same time, so the main traffic space of the ward not only needs to meet the traffic requirements of patients, but also needs to consider the requirements under the combination of multiple traffic modes (see the figure below for details). As shown in the figure, ① - ③ is the most common way of passage in the ward. The required clearance width is about 1200mm, which can meet the passage requirements in most cases. Fourth, the width of the passage is looser than the first three, which is a more comfortable scale. The ⑤ and ⑥ kinds of traffic width reached 1800mm, this scale can meet the traffic demand in various cases and ensure that the traffic will not be crowded, spacious and comfortable, but the premise is that the ward space is more spacious, otherwise it will take up the space size of other parts of the ward.



Different passage way and it's width

If the door of the ward is too large, it will affect the layout of the ward. If the door is too small, it can not meet the general needs. According to the above analysis, considering the possibility of meeting a variety of traffic and the actual situation, the width of the ward door should not be less than 1200mm. In the case of adequate width of the door, the width can be increased to 1200-1500mm. The width of the toilet door should meet the common needs of escorts to help patients go to the toilet, and the width should be 900mm. According to our observation, the width of ward door in actual use is generally not more than 1200mm. In this case, single ward door is more convenient to use than the form of

unequal double door. Therefore, the ward door should be set as 1200mm single door, if the need to be set as the unequal double door, should be selected as 900+300mm specifications, in order to ensure that only open the big door can meet some basic needs. When the width of the ward door increases to more than 1200mm, it is advisable to set it as the unequal double door. Because the patient may appear when using toilet accident, the toilet door appropriate is used outside open the door or sliding door.

(2) Size of window

In addition to meeting the requirements of lighting and ventilation, the design of ward windows should be considered so that patients can see the scenery outside the window. Especially for some patients who are more serious and can only rest in bed for a long time, it is appropriate to reduce the height of the windowsill so that this part of the patients can see the scenery out of the window. Domestic commonly used bed height can be adjusted in the range of 500-750mm or so, so when patients rest in bed, the height of the windowsill below 500mm can better ensure the patients staying in bed to view the scenery outside the window.[4] The New York hospital ward, pictured below, features a low windowsill that allows patients to lie in bed and still have views of the outside. According to the survey of inpatients, most of the interviewees prefer floor-to-ceiling windows, and the design of windows in the ward is more conducive to obtaining natural light.[35] Therefore, the windows should be set as French windows or glass curtain walls, corner windows, etc.; If the window needs to be set as a windowsill, the windowsill height should be controlled below 500mm, and the height of the protective railing should not be less than 1100mm (the height of the railing is calculated according to the relevant specifications).[35]

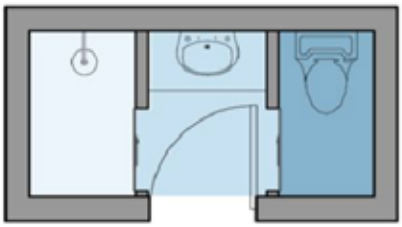
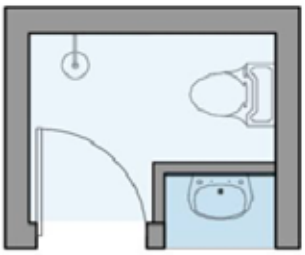
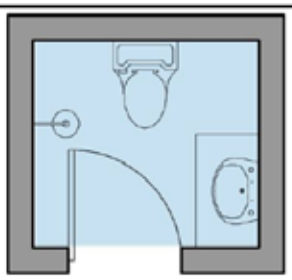
The low window design in the ward of New York Hospital[35]

-Size of toilet

(1)The way of layout

In ward toilet, basically offer wash bath, be like toilet and wash gargle 3 functions. As an auxiliary facility for inpatients' daily life, the bathroom scale should be arranged in a compact and reasonable way on the premise of satisfying the use function, so as to improve the use efficiency of space. According to wash bath, be like toilet, wash gargle 3 part function to organize means is different, toilet basically has 3 kinds of decorate means (as follows table place shows). The way that divides type layout its advantage depends on undertake space 3 kinds of different function, different user in theory can use shower, toilet or washbasin respectively at the same time. However, according to the survey and observation, ward toilet is different from the use of ordinary residential toilet, a considerable

number of patients need someone to assist them to use the toilet, so it is difficult to truly achieve their independence in the actual use, and this arrangement is adverse for saving space. Separate type decorates means to wash washbasin separation comes out setting, the type between photograph score can achieve the effect that uses independently, can save the area that part toilet needs, but the problem that exists is to decorate to go against keeping indoor neat and dry separately, open wash gargle space has certain noise effect to ward interior.In comparison, the centralized toilet is more suitable for use in wards. There are fewer contradictions in using sanitary ware at the same time in wards with fewer beds. Management and cleaning are also more convenient.

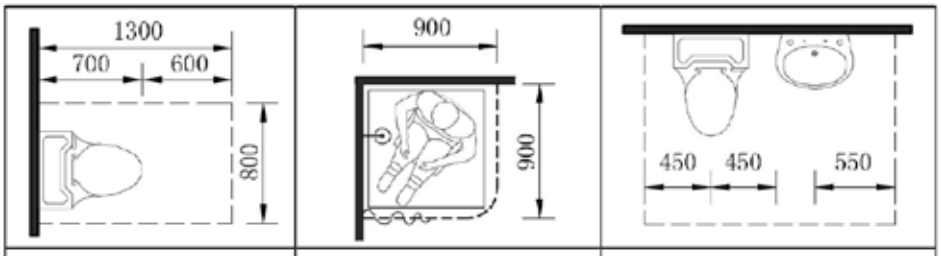
type	divide type	separate type	centralized type
diagr-am			
remark	Set the function of washing bath, toilet and washing separately	Isolate the washing function	All three functions are set together
relevance grade	×	√	√

Three kinds of the toilet's layout scheme[35]

(2)Active space size

The various activities of people in the toilet mainly revolve around the toilet, washing and bathing three functional areas, so the size of the toilet space, washing space and washing space in the ward toilet is analyzed as follows.In addition, ward washrooms are different from ordinary washrooms, and the corresponding barrier-free design should be carried out considering the use needs of patients, a special group of people.

Space size of toilet: Although squatting toilet is cleaner in the ward, more toilets are used closestool for the convenience of patients with poor self-care ability.When the toilet side against the wall, in order to complete the action of sitting, standing up, turning around, the distance between the vertical edge and the opposite wall should not be less than 500mm;When the toilet is located in the middle, there are no barriers such as partition or wall on both sides, in order to be able to pass from the front, the distance from the front to the opposite obstacle should be greater than 600mm.The width that ordinary person left and right two elbows hold open is 760mm, it is better to satisfy use, appropriate of smallest net area of toilet space dimension is 1300mm×800mm (as shown in the following table). In addition, a safety grip bar should be installed next to the toilet, and an emergency call facility and an infusion hook should be installed in the toilet.[35]

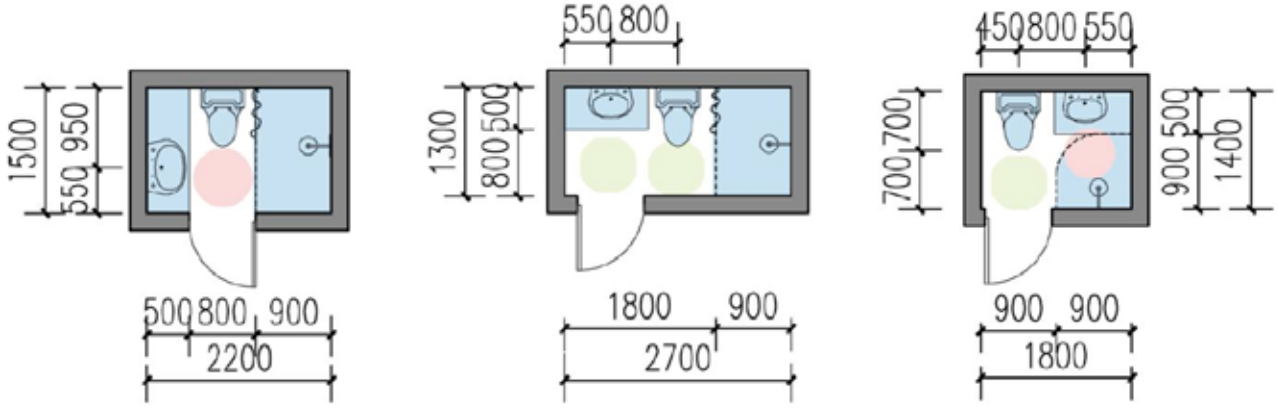


Seat toilet space size	Bath space size	Washing space size

The spatial size of relevant space in the toilet[35]

(3) Sanitary ware combination and size

The different combination way between clean is provided in toilet is affecting what its need area size is different. Figure place shows, the combination means between clean is provided basically have surround close decorate, straight line decorate and corner decorate 3 kinds of means. The enclosure arrangement is to arrange three kinds of sanitary ware around a common center, so that the washbasin and the toilet can share the use of space (shown in the red area of the figure); Straight-line layout means can reduce toilet width, but can increase depth, go against wash gargle, implement and shower functional space common; The way that corner arranges and surround close decorate similar, can undertake 3 kinds of functional space certain overlap decorate, economize use area. Accordingly, use a space for efficient ground, ward toilet clean provides combination means appropriate to consider first to use surround decorate or the way that corner decorates.



a. enclosure/3.30m2 b. straight line/3.5m2 corner/2.52m2

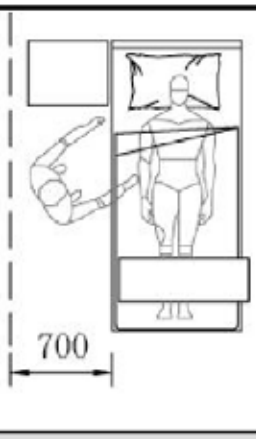
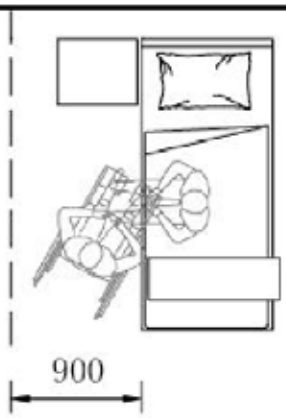
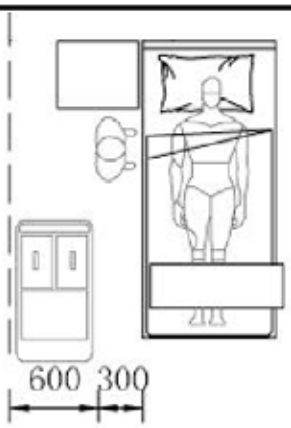
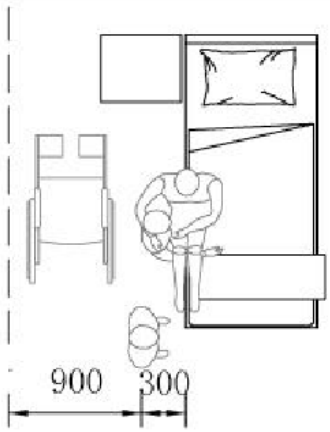
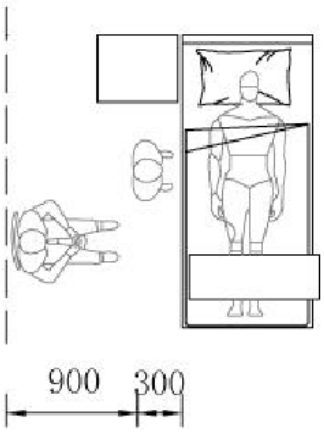
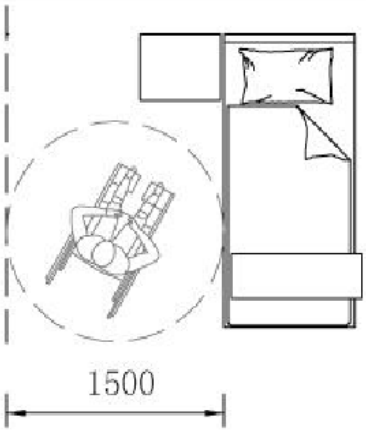
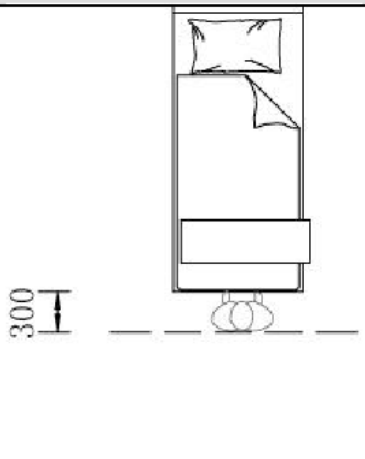
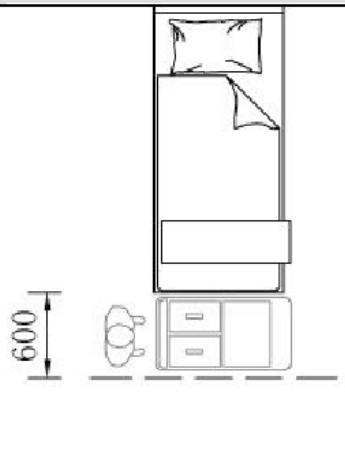
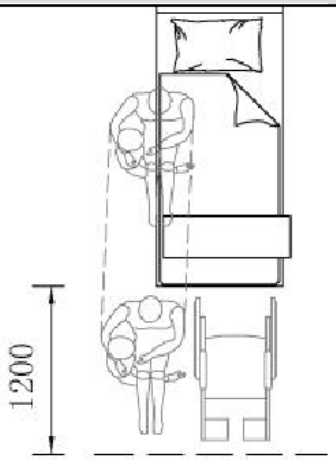
The combination way of sanitary fittings in the toilet

-Ward scale

The appropriate scale of the ward not only affects the economic rationality of the whole ward building, but also has a great influence on the comfort of the users. The scale of ward plane is mainly determined by the width of traffic, the space around the bed, the bathroom and the rest space.In addition to the plan scale, in order to ensure that the indoor clear height of the ward meets the specifications and requirements of use, the influence of the later equipment installation and ceiling decoration on the clear height should be taken into account in the floor height design, so as to select the corresponding floor height.[35]

(1) Activity space beside the hospital bed[35]

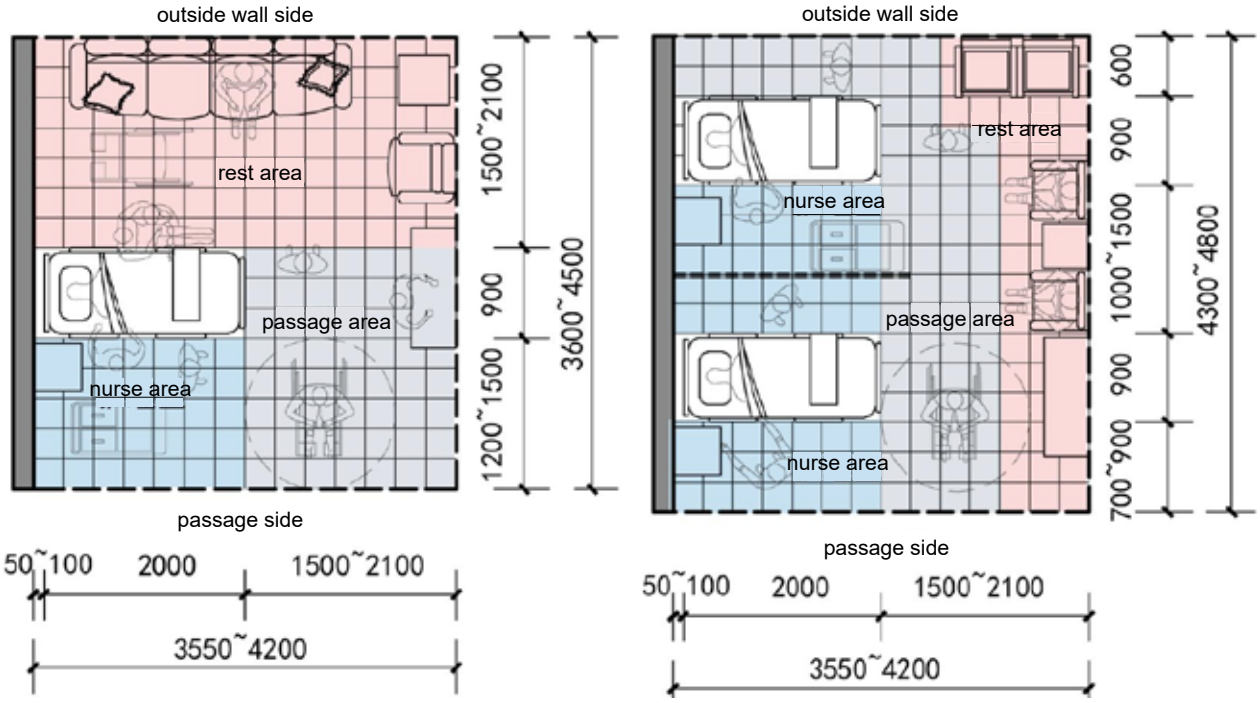
The main activities of medical staff, escorts, visitors and patients revolve around the space around the bed, and are mainly on both sides of the long side of the bed.Around in bed, nursing staff need to complete the corresponding nursing operation, parking cart, family members, visitors in the rest or to communicate with patients, the patient's own also need to finish up and down in the bed of the bed movement, for disabled patients sometimes need to use tools or to help others, all of this to the scale of the bed space have different requirements (see table below).

		
Basic nursing	Patients use wheelchairs to get in and out of bed	Place cart and side passage
		
Assist patient with wheelchair use	Relatives rest with side passage	The wheelchair rotary
		
Slide passage	Front access or cart placement	Assist patient with wheelchair use

The spatial scale of the space near the sickbed[35]

(2) Appropriate bed space size[35]

The multi-room is different from the single room in furniture arrangement and space use. Based on the analysis of the space scale required by different activities beside the sickbed, the author draws the space plane around the bed suitable for the single room and the multi-room according to the use and layout characteristics of the single room and the multi-room. As shown in the figure below, the bed-side space near the corridor in a single room is the main nursing operation space for staff because it is close to the entrance of the ward. Patients usually get up and get out of bed on this side, and its width should be 1200~1500mm. Furnishings such as sofas and tea tables should be placed in the space near the outer wall to serve as the rest area for escorts or visitors. Its width should be 1500~2100mm. The width of the passage in the ward should be convenient for wheelchair occupant. Although there is no need to arrange seats on the wall at the end of the bed in a single room, appliances and furniture facilities are usually relatively perfect in a single room. The placement of these facilities should be taken into account, and the width should be 1500~2100mm. In addition, to facilitate cleaning and swabbing, still need to put aside 50~100mm between the head of a bed and the wall.In the multi-bedroom, the main care area includes both the bedside space near the corridor and the shared area between the two beds. In order to complete the basic nursing work, the width of the nursing area by the corridor side should be 700~900mm, and the nursing area shared between the two beds should ensure that the normal use will not be affected when the curtain is pulled, and the width should be 1000~1500mm. In multiple rooms, if the rest area for escorts and visitors is set on the side of the external wall, it can only be used by the family members of the most outside patients. In fact, many wards arrange chairs and some furniture on the wall at the end of the bed. In this case, the net width between the end of the bed and the opposite wall should not be less than 2000mm. For multiple people with beds arranged on both sides, it is stipulated in the specification that the net width of the corridor between the end of the bed should not be less than 1400mm, and more than 1500mm should be guaranteed in real life to leave room for wheelchair rotation.

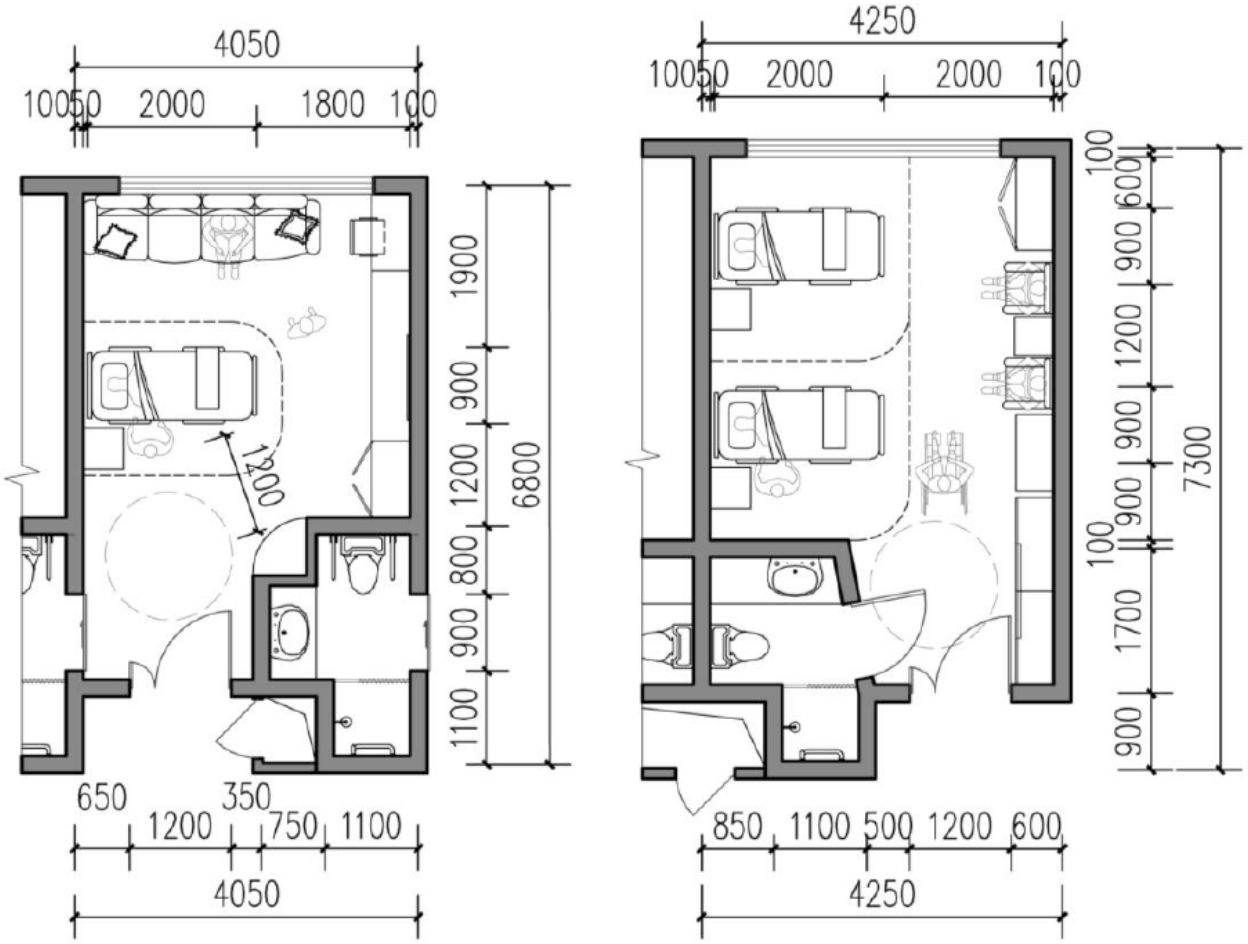


a. single room b. double room

The suitable size of the space near the sickbed[35]

(3) Ward plan and size[35]

According to the above analysis, the width of single row beds should be 3550~4200mm, and the width of single row beds should be about 4050~4200mm. The net width of the sick room with double arrangement of the sick bed should not be less than 5600mm.In the analysis of the bathroom size of different wards in the last section, the length of the bathroom to meet the basic use needs varies from 1700 mm to 2500mm, so the length of the ward will vary according to the number of beds and the bathroom layout. Based on the analysis of different activities and spatial scales in the ward above, the author draws a suitable single room and double room ward plane for reference, as shown in the figure below. The single room in the picture takes into account that it is easy for medical staff to observe and convenient for patients to go to the toilet. The toilet and the bed are arranged in a dislocation, and the ward door is set as a 900mm wide sliding door for easy use. The ward entrance is concave to form a certain buffer space. Double room the same entrance concave, but unfavorable beds and dislocation toilet decorate, this will increase the nursing care distance, placing bathroom entrance wall inclined to improve the problem of toilet is blocked, metope is decorated by the end of the bed side cabinets, chairs and the furniture such as tables, daily use convenient for patients and their families. In the actual project, the width of the inpatient ward greatly affects the size of the column network of the ward building, and the size of the column network also has an impact on the economic layout of the underground space parking space, so it is advisable to make corresponding adjustments in the design according to the specific situation. According to Italian law the net area of a room must be equal or more than 18 squre meters.



The suitable layout of the wards[35]

3.7.2.3 Barrier-free Care

In the design of public buildings, the accessibility of the disabled should be taken into full consideration. Especially in the design of hospital nursing units and wards, the users are mostly vulnerable groups with poor health and are likely to use wheelchair and other auxiliary facilities. Therefore, the barrier-free design in the inpatient ward environment is particularly important, which reflects the humanized care for patients. It is the general trend of social development for accessibility to universal design. Therefore, the physiological and psychological characteristics of different groups should be fully considered in the accessibility design of ward environment, and the concept of universal design should be introduced. Referring to the relevant information of accessibility design at home and abroad, we classifies and summarizes the key points of accessibility design related to ward environment as follows. [35]

-Corridor outside the ward[35]

In barrier-free design, the width of indoor passageway should not be less than 1.20m, and the width of indoor passageway in large public buildings with more or more concentrated people should not be less than 1.80m. Combined with relevant regulations, the corridor outside the ward should be considered to meet the requirements of pushing bed, so its net width should not be less than 2.40m, if there is a height difference should be used to connect the ramp, and according to the design of barrier-free ramp. In the ward corridor that wheelchair user often comes in and out, unfavorable set thick carpet, the ground should level off, prevent skid, glance is small or without glance. The walls on both sides of the ward corridor should be equipped with armrests against the walls and anti-collision facilities.In addition, the height of the objects or signs fixed on the walls and columns on both sides of the corridor should not be less than 2.00m from the ground; If less than 2.00m, the width of the probed part should not be greater than 100mm; If the protruding part is greater than 100mm, the height from the ground should be less than 600mm.

-Ward door

The ward door should open directly to the corridor, its width should not be less than 1.10m, and should be set up observation window. In order to facilitate the access and rotation of wheelchair users, the interior and exterior space of the door and the wall should meet the corresponding requirements of the accessibility design points. At present, the color of the ward door of some nursing units is close to the corridor, which is not conducive to visual identification. It is advisable to choose the color with a certain contrast to the corridor, and pay attention to the installation of protective door panels and closing handle (as shown in the figure below). The height of the protective door plate can be adjusted to 900~1200mm, taking into account the influence of the pushing bed in the ward. [35]

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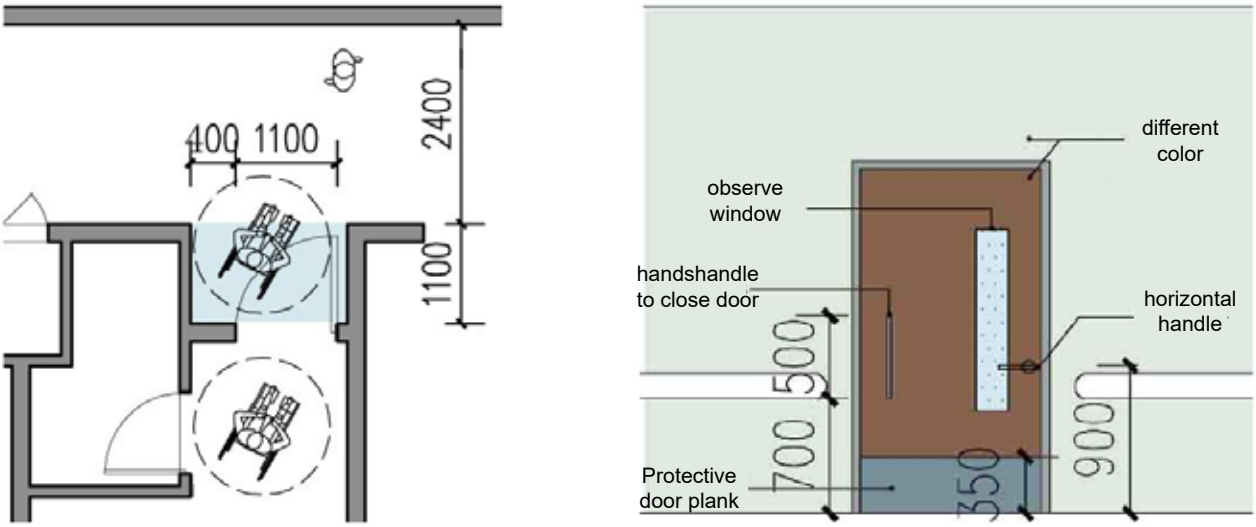


The ward door and the space around which combine the barrier free design points[35]

-Toilet

The requirements of accessibility design for toilets are mainly reflected in two aspects. On the one hand, the layout of internal space, sanitary ware and facilities should consider the human scale of wheelchair occupants, and be appropriate in terms of size and height. For example, the height of the toilet and the seat or seat in the bath area should be the same as that of the standard wheelchair, which is set at 450mm. On the other hand, in order to assist wheelchair users or patients with poor health conditions in using toilets, safety handrails should be provided in all areas to support them.

-Inside ward

At present, most hospitals use the bed height can better meet the needs of different patients. In single rooms, there are fewer people and accidents are not easy to be found, so it is advisable to add an emergency call button in the room. In addition, the height or switch position of the main furniture and electrical appliances in the ward should be considered in combination with the accessibility scale, and the vertical height should be controlled between 700mm and 1100mm.[35]

In order to meet the requirements of barrier-free design, the size of ward toilet and interior space often needs to be increased on the basis of conventional design.However, it is inevitable that there will be limited conditions in the actual project and the spatial scale cannot fully meet the requirements of accessibility design.Although the increase of space area is relatively limited, it is relatively easy to implement the accessibility design in terms of installation of facilities, related height control, safety handrail installation, etc. Therefore, the key points of accessibility design should be satisfied as far as possible in the design. For the barrier-free design in the healthcare environment, besides should be combined with human body engineering according to the rules of space and scale, the corresponding auxiliary facilities installation, considering also should from the indoor and outdoor environment, human behavior and the emotion demand, the respect such as the details of the humanized design to reflect, to achieve the physical and psychological barrier free.

3.8 The application of intelligent hospital in our design

3.8.1 Development status and future trend of hospital intelligence

The intelligent system of hospital has been expanded to more and more extensive fields from the past intelligent building and simple electromechanical equipment management. Now the intelligent hospital construction based on the Internet of Things technology has entered people's vision.The intelligent system of hospital has rich contents, wide coverage, strong professionalism and rapid development.It is an important part of hospital reconstruction and expansion and hospital digitization project, and it is also the difficulty of hospital digitization construction.How to adapt to the development of The Times, the establishment and implementation of intelligent hospital system, the construction of digital intelligent hospital is a problem of concern.

3.8.1.1 Connotation of intelligent hospital

The connotation of the intelligent system of the hospital is becoming more and more abundant, and the extension is constantly expanding, gradually integrating management, clinical and logistics management, including intelligent buildings and other fields. The scope of hospital intelligent system is divided into broad and narrow sense in the industry.

The generalized hospital intelligent system includes two aspects of hospital informatization and building intelligentization, while hospital reconstruction or expansion or traditional intelligentization pay more attention to the narrowly defined hospital intelligent system, that is, the design, deployment and construction of information infrastructure , The digital and intelligent management of electromechanical equipment, the special application system of hospitals associated with building functions, etc., lay the foundation for the effective application and future expansion of core application systems such as hospital management information systems and clinical information systems.

3.8.1.2 Main composition of hospital intelligent system

The construction of the hospital's intelligent system is a comprehensive medical project. It is the total integration of the building's intelligent system. Each system contains a wealth of subsystems, which are integrated with each other to form a complete hospital intelligent system. Only the intelligent construction of hospitals can achieve the ultimate goal of hospital digitization.[36]

For the classification of hospital intelligent systems, there are currently many methods. According to the technical categories of hospital intelligent subsystems, the intelligent systems can be subdivided into seven types of subsystems, mainly including:

Network communication system

The network communication system is the most basic hardware facility in the computer system.Providing reliable communication transmission channel and network platform for other intelligent systems.It mainly includes: integrated cabling system, computer network system, main storage system, information security system, voice communication system, digital network clock system, etc.

Security system

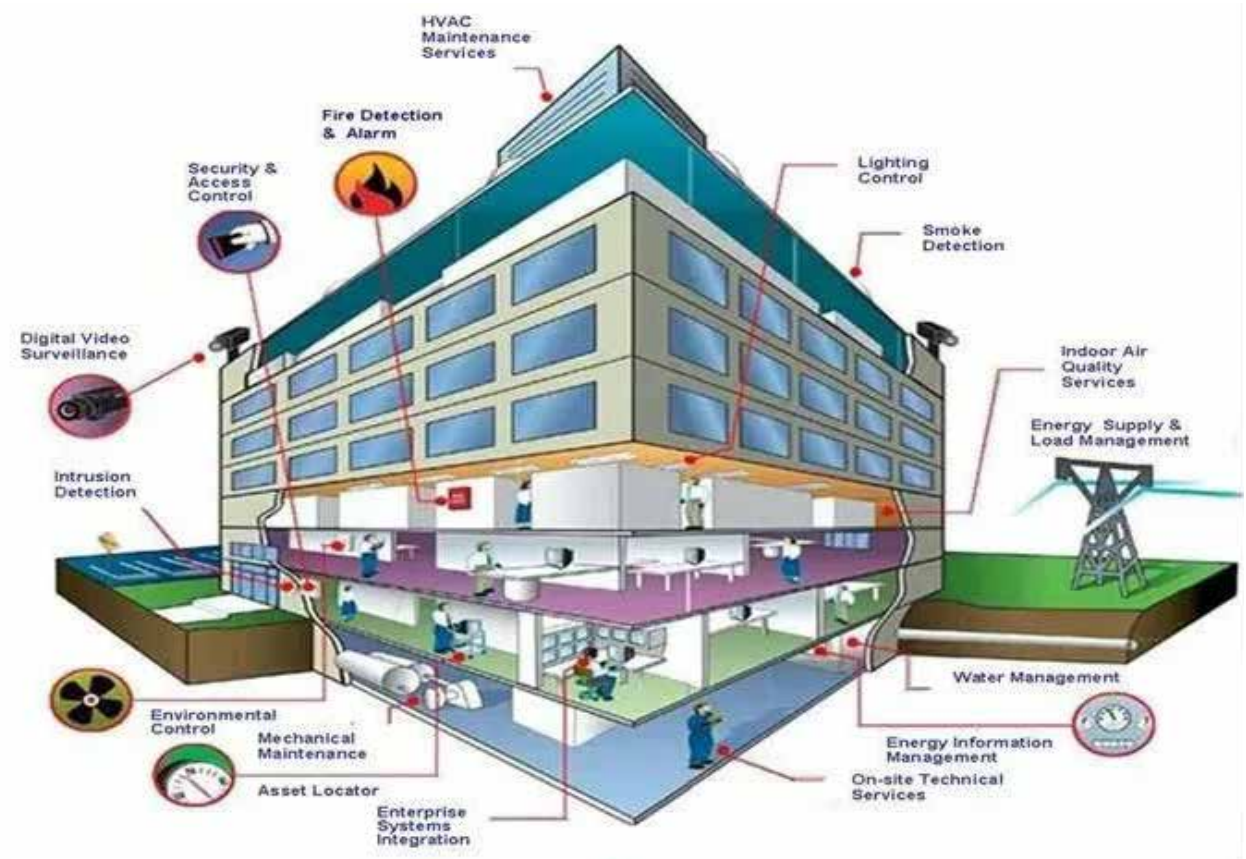
The security prevention system is designed and constructed for a series of issues such as high turnover of hospital personnel, complex identities, prone to theft and other security incidents, and the inability to obtain evidence after medical disputes occur.

Multimedia audio and video system

Multimedia audio and video systems are mainly a collection of audio and video subsystems, including hospital multimedia conference systems (administrative office meeting rooms, academic lecture halls, etc.), media display systems, cable TV systems, and public broadcasting and background sound systems.

Building Automation System

The building automation system is a system that monitors the main electromechanical equipment of the hospital building, creates a comfortable



building automation system[36]

environment for the hospital, and plays a role in energy saving and scientific management. It is mainly composed of building automation system, meter reading and measurement management system, intelligent air-conditioning energy-saving management system and intelligent lighting control management system, medical gas monitoring management system, hospital logistics transmission management system, building intelligent integrated management system, etc.

Hospital dedicated system
The hospital dedicated system is an intelligent system that provides specific medical functions. It is closely related to the hospital's business and processes and is very professional. It mainly includes: call system, triage queuing system, overall digital surgery department and surgery teaching system, visitation System, mother-child matching and infant anti-theft system, patient positioning system, all-in-one card system, etc.

Computer room project
The computer room project is mainly composed of the information center computer room, the security control center computer room, the building electromechanical equipment management computer room, and the floor access computer room. Including computer room wiring, uninterrupted power supply, fire protection, lightning protection, anti-static, intelligent monitoring and other systems.

Hospital information application system
Hospital information application systems can be divided into hospital clinical information system, hospital operation management information system, hospital customer service information system, hospital knowledge management information system, hospital logistics support information system, regional medical collaboration information system, Internet of Things application information system, etc. Each system involves a series of application systems. For example, the hospital operation information system mainly focuses on the subsystems related to hospital flow, logistics, capital flow management and daily operations, including a series of subsystems such as HIS, HRP, and OA.[36]

3.8.1.3 Current situation of hospital intelligence in China

Regarding the status quo of the intelligent development of Chinese hospitals, since the 1980s, domestic hospitals began to use computers to participate in hospital management, gradually developing from a stand-alone system to a network system, from a financial settlement-centric business management system to a patient-centric clinical Information system transition.

Since the beginning of the 21st century, hospital informatization has entered a period of rapid development. The application of information technology has continued to spread, covering almost all medical institutions. The application of informatization in hospitals has expanded from management to clinical, scientific research, teaching, logistics and other fields. The application of line segmentation is developing towards the construction of large-scale integrated and open hospital information system, from a single hospital to the coordinated development of regional medical care, from pure data collection and storage to the development of intelligence based on data mining, the introduction of Internet of Things

technology, It has opened up another broader space for the digitalization of hospitals.

3.8.1.4 Development trend of hospital intelligence

With the rapid development of China's economy and the highly developed level of science and technology, providing high-quality medical resources to serve people's livelihood has become the consensus of the government and the society.

In the new medical reform, it is clearly proposed to further improve the medical environment, control the growth of medical costs, and improve the management level of medical resources with information technology. Taking this as an opportunity, smart hospitals emerge at the right moment and quickly become a hotspot of construction.

Wisdom hospital overall architecture, on the basis of network cabling, on the one hand, the integrated hospital building intelligent systems and intelligent auxiliary system for hospital to provide a safe and comfortable medical environment of green low carbon, on the one hand, acquisition technology, automation of the medical equipment and medical workstation offers a variety of clinical data, realize the optimal treatment process optimization, the medical quality, work efficiency is highest, the medical records electronically regionalization, scientific decision-making, office automation, network, software standardization.

Compared with traditional hospitals, the intelligent construction of hospitals can achieve: effectively improve the hospital's medical environment and air quality; save energy consumption by 20% to 30%, including water, electricity, gas, medical gas, etc.; shorten the waiting line of medical patients Time; improve the efficiency of information query and statistics; reduce the loss of drugs due to management reasons; reduce the logistics loss caused by management reasons by more than 60%; reduce the error rate of financial, medical advice, price allocation, and drug delivery caused by human reasons; greatly Improve the efficiency and accuracy of leaders' decision-making.[36]

3.8.1.5 The inevitable trend of hospital informatization in the future

In recent years, the development and popularization of information technologies such as the Internet, the Internet of Things, cloud computing, and big data have created a new situation in hospital informatization. As a new concept, "smart medical care" has gradually become the trend of hospital informatization construction. Intelligent technology is widely used in various departments and departments of hospitals.

At present, the construction model of smart hospitals in China can be roughly divided into three categories: one is smart hospitals based on single hospitals (hereinafter referred to as smart hospitals); the second is to establish smart hospital groups based on smart hospitals and medical consortia; and the third is coverage Smart medical service system in a certain area. The following editor will introduce these three modes respectively.

I. Smart Hospital

1. Smart service. Hospitals, especially tertiary hospitals, use the Internet and Internet of Things to provide patients with services such as appointments for diagnosis and treatment, waiting reminders, hospital navigation, inspection and inspection results, price payment, health education, etc., making the medical service process more convenient and efficient .[37]

2. Smart medical care. First, by integrating data from various medical systems in the hospital, when there are conflicts in diagnosis, medical records, medications, inspections, and inspections, it can remind doctors in real time to reduce medical errors. The second is to establish decision models based on big data and artificial intelligence technology, integrate evidence-based medicine knowledge bases, and realize intelligent diagnosis and treatment decision support to ensure medical safety. The third is to integrate voice recognition into the electronic medical record system. Doctors input medical records through voice, and the system recognizes voices and converts them into text in real time, improving the efficiency of clinical diagnosis and treatment. Fourth, through mobile doctor workstations, medical applications such as mobile ward rounds, mobile ECG, and mobile imaging are realized. Doctors can access medical records of inpatients in the undergraduate room from anywhere, and use fragmented time to improve efficiency.

3. Wisdom care. One is the use of IoT sensing and wireless communication technologies to develop intelligent infusion systems, intelligent bed monitoring systems, and patient temperature monitoring systems. Replace manual monitoring with intelligent and dynamic wireless monitoring to improve hospital care efficiency and ensure medical safety. The second is to use chip wristbands + Internet of Things technology to turn nurses' manual checks into automated checks to reduce medical risks. Nurses can use mobile phones to directly complete all kinds of records, and the data can be automatically synchronized to the system. Evaluation sheets can be automatically generated for the collected data, reducing multiple entries and improving nurses' work efficiency.

4. Smart management. The hospital uses big data technology for internal management, which is equivalent to being equipped with a "smart housekeeper" to help the hospital carry out refined management and improve its comprehensive

management level. For example: the hospital's integrated operation management system, which can realize the traceability of the whole logistics process of medicines, reagents, consumables, articles, etc., asset life cycle management, financial business integration linkage, income payment management, budget management, cost accounting, and improve the coordination of operation management departments Efficiency, supporting comprehensive operational analysis and management decision-making; medical waste management system and intelligent linen management system, based on the Internet of Things technology, to achieve the entire process of closed-loop operation and full-process management of medical waste and linen; intelligent equipment monitoring system and intelligence Energy management and control system, using IoT sensing technology to monitor and intelligently control medical equipment, water, electricity, gas, heating and other infrastructure and equipment in real time; intelligent security system, with video surveillance image big data as the core. Through face recognition and other technologies, assist the public security organs in catching all kinds of illegal fugitives, and effectively protect the personal and property safety of patients and medical staff.[37]

II. Smart Medical Group

At present, it is mainly in the urban medical group. The leading hospital has established a remote platform to provide remote consultations, two-way referrals, remote imaging, remote teaching, popular science education, video conferencing and other remote services for the member units of the medical group to help improve primary care Service Level.

On the basis of the telemedicine platform, a two-way referral system was developed to provide services such as appointment diagnosis and treatment, two-way referral, query of medical records, and query of inspection results for member units in the medical union, realizing the hierarchical diagnosis and treatment of upper and lower linkage, emergency and slow treatment pattern.[37]

III. Smart medical service system

Mainly relying on the regional information platform to connect the hospital’s electronic medical record system and the residents’ electronic health file system to realize the interconnection and sharing of medical and health information generated by hospitals, primary medical and health institutions, and patients’ homes in a certain area, so as to realize the reception of any medical institution in a certain area Doctors can obtain information such as patients' health files and past medical records to assist doctors and family doctors in major hospitals in their work.

The important support is the regional information platform and mobile medical equipment. The regional information platform realizes the interconnection of information among different medical and health institutions; portable medical equipment and wearable devices can collect blood glucose, blood pressure, ECG and other data of patients at home in real time to improve Patients' self-management awareness and level, and prompts and health education on health risk factors related to their lifestyles, provide residents with full-cycle, precise

medical and health services.

The smart hospital will be an excellent medical center in the medical service system in the future

A smart hospital is not a comprehensive institution for all medical services, but a medical center that specializes in providing high-value services in the medical system. Its core will be positioned in intensive care, surgical treatment, and diagnosis and treatment of difficult diseases. In this system, simple disease diagnosis and operation can be undertaken by clinics or specialist hospitals, auxiliary testing can be undertaken by third-party institutions, and disease prevention and health management can be carried out at the patient's home. The connotation of the future smart hospital should include five elements: inter-institutional interconnection, automated and efficient operation, reshaping the experience of the whole process, big data-driven decision-making, and continuous innovation mechanism.

Under the premise of legal permission, ensuring the real-time sharing and interconnection of medical data among various institutions is of great significance for patients to achieve high-efficiency, fast and convenient, and high-quality services.

The hospital is a labor-intensive organization. The smart hospital will use its basic fully automated equipment to operate and serve, improve the service efficiency of the hospital, reduce costs, and its services can break through the boundaries of the hospital and extend to every link before, during, and after treatment. , Can make up for the shortcomings by accessing the data of other institutions in the medical system, and continuously improve the quality of care, patient experience and clinical procedures and other medical services, while also effectively controlling costs.

Strengthen the construction of smart hospitals, improve the hospital's refined and informatized management level, and make the process more convenient, the service more efficient, and the more refined management as much as possible, thereby further enhancing the people's sense of medical treatment.[37]

3.8.2 Application of robotics in hospitals

3.8.2.1 Types and functions of robots

In recent years, the use of robots in all walks of life has become more and more extensive, and some industries have partially or completely replaced humans. In the medical industry, the use of robots is also in full swing. Many domestic hospitals have introduced robots to help their development. As far as the types and functions of the introduced robots are concerned, they can generally be divided into three categories: guidance robots, logistics robots, and surgical robots.

I. Medical guidance robot

In terms of gold content, among the three types of robots, the diagnosis guidance robot is undoubtedly the lowest, and it is also the most introduced by the hospital. From the point of view of its function, the diagnosis-guide robot is mainly arranged in the outpatient area, and the users are mainly outpatients. In the past, outpatient guidance work was basically undertaken by the guidance nurse. Although the job is not difficult, it tests the patience of

nurses. The hospitals often do not pay high treatment to the guiding nurses, so the staff mobility is extremely high. The use of medical guidance robots can replace most of the work of medical guidance nurses.

The guidance robot can perform the following operations:[38]

medical guidance robot[38]

1. Preliminary triage: The diagnosis guidance robot generally has a built-in triage knowledge base, which can recommend appropriate departments to patients for treatment based on the description of symptoms;

2. In-hospital location navigation: The hospital map is loaded into the diagnosis guidance robot, which can provide patients with route and destination guidance.

3. Common question consultation: In addition to the above two functions, the diagnosis guidance robot can also introduce the basic functions of the patient to the patient's medical process, provide doctors' consultation information, and check appointments.

logistics robot[38]

II. Logistics robot

In hospitals, the transportation of medicines and consumables is also a headache. The practice of most hospitals is to set up in-hospital distribution centers to use manual distribution or to outsource the distribution business. The use of manual delivery is time-consuming, laborious and labor costs are getting higher and higher. Now that the use of robots in the logistics industry has become more and more common, many hospitals have also been inspired by it and introduced robots into hospital logistics.

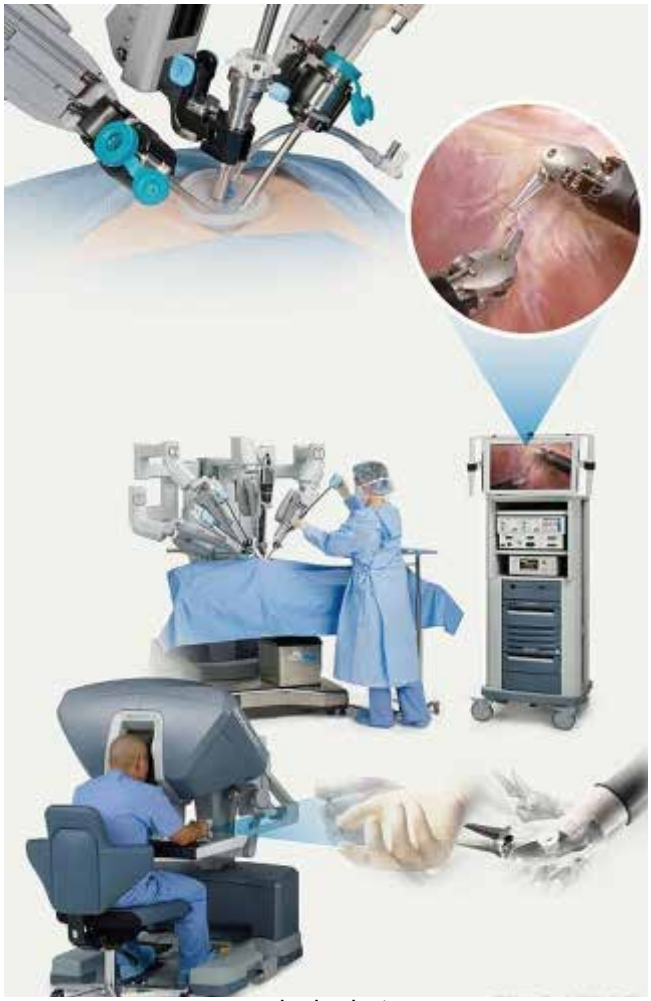
Compared with manual transportation, the logistics robot has the characteristics of strong load capacity and various types

of goods to be transported. In addition, it can also perform real-time monitoring of the distribution process in the hospital. This is essential for the transportation of high-value and dangerous medical items. Logistics robots can automatically plan routes through a variety of positioning methods, avoid obstacles and pedestrians during transportation, ride on elevators, and provide alarm reminders.[38]

III. Surgical robot

Surgical robots are undoubtedly the robot with the highest gold content in hospitals, and they are increasingly becoming a symbol of hospital strength. After all, tens of millions of equipment are not affordable by any hospital, and surgical robots also have certain requirements for users. In the field of minimally invasive surgery, surgical robots have obvious advantages.

Strictly speaking, the current surgical robots are far from the intelligence of the robots we have seen in film and television programs. Take the Da Vinci robot that many people are familiar with as an example. The surgical robot is more like a simulator. The surgeon puts the double gloves into the finger cuffs in front of the operating table, and the mechanical arm makes corresponding actions with the finger cuffs to complete the operation. For the doctor, the operation can be performed while sitting without direct contact with the patient, and the hand shake during manual operation can be filtered out, which can provide a clear view of the operation. The biggest drawback of surgical robots is that they are too expensive. Using Da Vinci robotic surgery, the cost of an operation is more than 20,000 yuan. This invisibly affected the popularization and use of surgical robots. However, with the implementation of various supporting measures, it is believed that the scope of use of surgical robots will become wider and wider.[38]



surgical robot[38]

3.8.2.2 Application cases of robots in Shanghai Children's Hospital

logistics robot deliver items to nurse's station in Shanghai Children's Hospital[39]

Traditional manual transportation of materials is the mainstream of current hospitals. Each hospital has a varying number of outsourced nurses, who are mainly responsible for the most basic tasks such as transportation and inspection. Regardless of the general status quo of the nursing industry, such as high liquidity and high replacement rate, there are also big problems in its working mode in terms of transportation alone. For example, mistakes such as wrong picking and wrong delivery of transported items are prone to occur; accounts are manually registered and there are no items. Traceability means and links, and the transportation carrier and lock structure are thin, easy to be damaged and intruded, and transportation safety is difficult to be guaranteed; additional clinical attention is occupied, which easily causes sensory control problems.

So, what are the hospital logistics methods that can improve efficiency and ensure safety? Yu Guangjun, Dean of Shanghai Children’s Hospital, introduced that on the basis of learning the new methods of artificial intelligence applied to logistics management in well-known hospitals at home and abroad, the hospital organized a series of scientific research innovations in a planned way, and finally chose the hospital logistics robot. Currently the most "fashionable" direction.

From February 2018, under the leadership of the project leader Yang Xiaodong, the deputy dean of Shanghai Children’s Hospital, the Shanghai Children’s Hospital Security Department declared to the Shanghai Municipal Science and Technology Commission’s Scientific Research Project (High-tech Field) "Intelligent Robots in Digital Hospitals" The "Application Research in the Construction of Smart Logistics" project and sub-projects were finally approved and approved.

The main research goal of the subject project is to take the lead in realizing the construction of a smart logistics system platform based on smart robot technology in Shanghai medical institutions, and to realize the practical application of smart robots in two business scenarios of hospital PIVAS drug delivery and general drug transportation .

With the cooperation and implementation of the scientific research cooperation unit-Shanghai Mumu Robot Technology Co., Ltd., as of September 2018, Shanghai Children's Hospital has completed all the preliminary deployment and commissioning work. 2 robots-"Tongtong" No. 1 and No. 2 officially started the whole process to automatically complete the distribution of PIVAS and inpatient pharmacies. According to statistics, during the operation period from September to December 2018, the "Tongtong" twins have been working normally for 93 days. They have been successfully delivered to the nurse station for 1,600 times and the total transportation distance is 218 kilometers, which is equivalent to the transportation distance from Shanghai to Wuxi distance, the average time is 26.1 minutes.

On January 14, 2019, the second phase implementation kick-off meeting of the logistics robot project was successfully held in Shanghai Children’s Hospital. Robots "Tongtong" No. 3 and No. 4 were added to the original basis. Now these 4 brothers have taken over the inpatient department of the hospital. Delivery of medicines to all wards on 10th floors to 13th.[39]

logistics robot is working in Shanghai Children's Hospital[39]

As the prototype of artificial intelligence in the logistics support field of the medical industry, hospital logistics robots are currently widely used in more than 150 hospitals in the United States and more than 200 hospitals around the world. They are mainly used to transport

various types of medical materials such as medicines, bedding and catering. , This time will also be applied to the Trofarello Hospital we designed.

From the perspective of hospital management, it greatly improves the efficiency of hospital logistics and transportation, freeing medical staff from the complicated and low-value-added labor; from the perspective of patients, the robust and safe-protected robot avoids the transportation process. The damage and theft of materials and other accidents happened; for the Shanghai Children's Hospital, the "children" robots that shuttled through the ward tirelessly have a certain comforting effect on the hospitalized children and become them. A "landscape" I look forward to every day during my hospital stay.

In the future, robotics technology may also be used in more medical scenarios such as medical waste disposal in hospitals, catering distribution, intelligent escort care, and medical guidance. Robot technology will also become an important part of digital hospitals, and has strong replication and reference value in similar hospital construction projects.

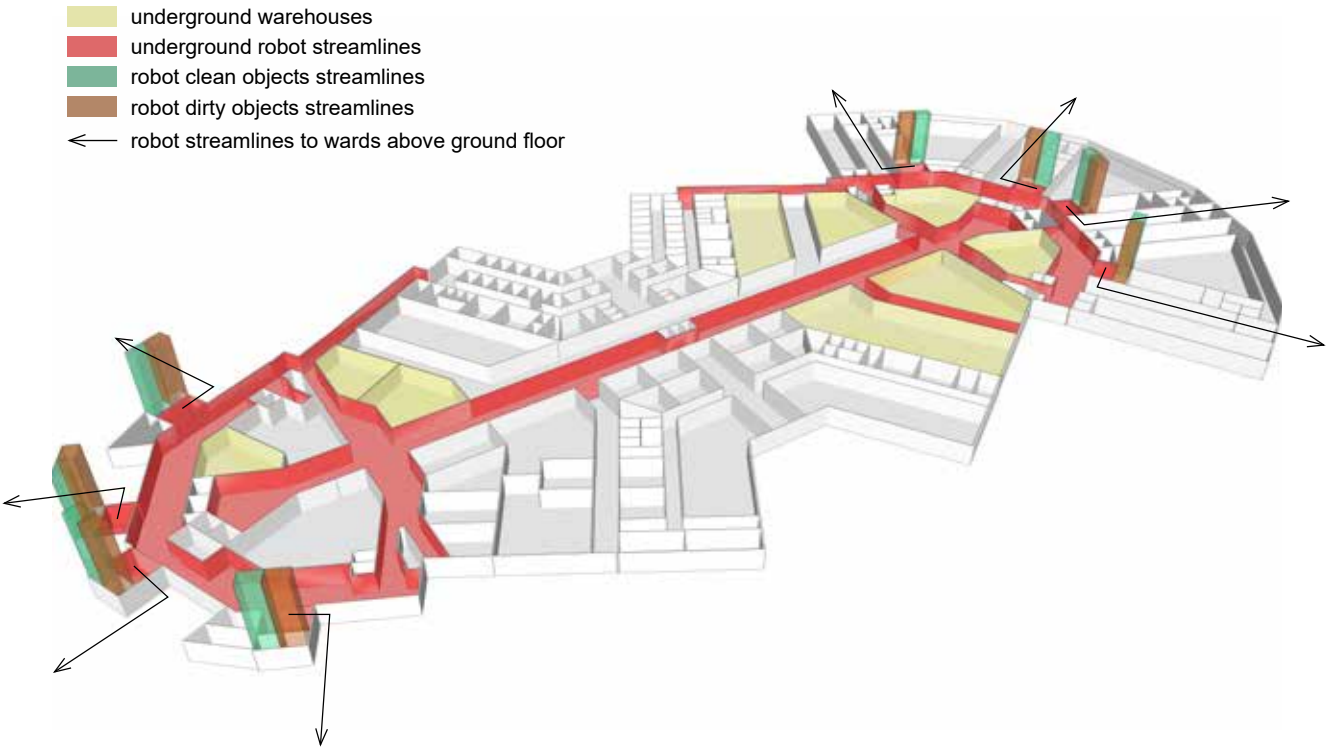
logistics robot at the door of Shanghai Children's Hospital(source network)

4.8.2.3 Application of robot in Trofarello Hospital design

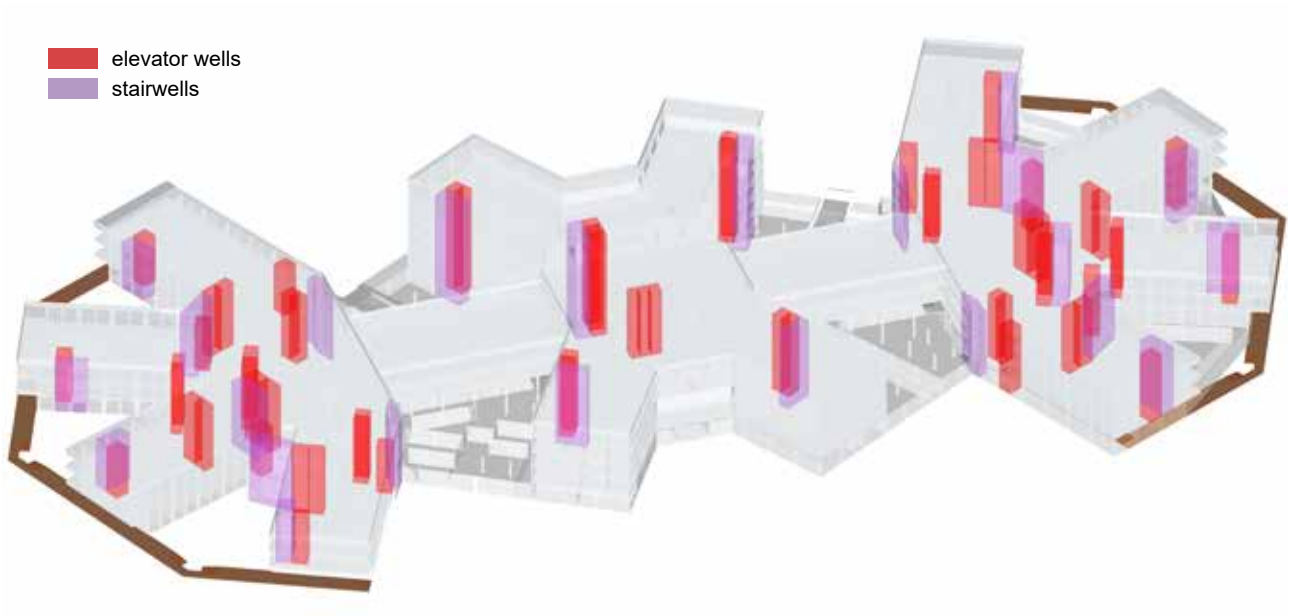
In this hospital design, we also used diagnosis guidance robots, logistics robots and surgical robots.

The medical guidance robot mainly serves the entrance hall and the outpatient area, and is mainly used for outpatient patients. Logistics robots travel between wards and underground warehouses to transport medicines, consumables and other items instead of medical staff. Surgical robots have the highest gold content, and some of them replace doctors in performing delicate operations that are difficult to operate manually.

We have set up two dedicated elevator rooms for logistics robots in each ward area, including two elevators and three robot charging areas. These two elevators transport clean materials and dirty materials respectively, and serve the clean area and contaminated area in a division of labor.



logistics robots flow from wards to underground warehouses in our hospital design



the distributions of elevators and stairwells

Chapter 4
The distribution and analysis of Trofarello hospital plan

4.1 Derivation of module hospital plan

4.1.1 Module A and B

1.Basic dimensions and column grid arrangement

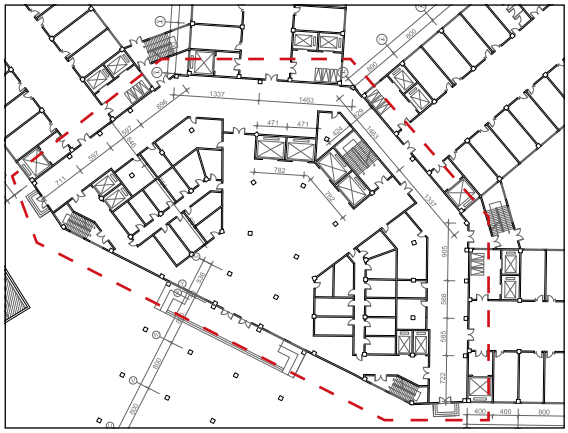
The area of A(B) is 2458 square meters, and the passage between A and B is 1408 square meters. The The basic column dimensions of the module is 8.0m x 8.0m.

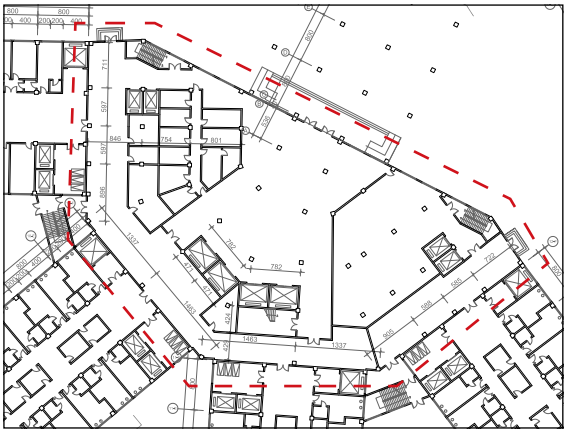
Basically two rows of rooms are arranged along the outer wall, and one row is arranged in the middle, forming a layout of three rows of rooms and two corridors. The width can be set flexibly of each room and passage according to function and people flow line.

2.The basic characteristics of AB

Irregular modules can allow more rooms to be set along the outer wall, making most rooms with good ventilation and lighting, strong interest and good vision. The middle part of the series AB enhances the connection and convenience between the modules.

4.1.2 Module C and D





1.Basic dimensions and column grid arrangement

The area of C(D) is 2172.3 square meters, combined with the ward areas. The The basic column dimensions of the module is 8.0m x 8.0m.

The circular courtyard is set at the middle of module, people in C D and those who come through the corridor can look directly into the landscape inside the courtyard. The ratio of the circular courtyard is 8m which is same as column grid.

2.The basic characteristics of CD
In the center of the module, there is a circular courtyard, located in the most crowded place, which runs through the whole hospital and is used to introduce natural light and beautify the space, making the space more hierarchical.Can make people feel happy.

4.1.3 Multiple gallery hospitalization module

1.Basic dimensions and column grid arrangement

In the scheme, the length and width of the multi-gallery plan modules are 40x24m respectively, and the module area is 960 square meters. The basic column network of the module plan is 8mx8m, 4m wide and 8m long, among which the length and width of the toilet is 2.5x2m.

In the middle of module, there are nurse workstation including drug area, dirty room, clean room, toilet, locker room and nurse office.Each ward region has canteen and consulting room. These functional rooms form two corridors with the wards at both ends.

2.The basic characteristics of ward

The room in the middle of the module is a nurse workstation set in the middle of two corridors, which is much more efficient than a single gallery plane. Canteen and consulting room is also designed in each ward area, which reflects the design concept of combining concentrated work core area with some scattered auxiliary functional areas in the graphic design.

According to the number of beds required by each department to determine the number of wards, the most part of the rooms in the wards can be used as single as well as double rooms. Some ward module ward is little, leave the space that gives patient activity so. Wards as large as possible in the same upper and lower floors, easy to walk and management. Special functions are also set in the wards of some special departments, such as the delivery room, predelivery room, baby room and family waiting room etc. In ICU, due to the crisis of patients' condition, only staff channel and family visit channel are implemented, and both of them need to change clothes and disinfect before they can be admitted to intensive care unit. Each ward module has two vertical traffic, one at the end of the ward area, the size of a bed; one is at the other end and on the other side, there are two elevators and stairs.

4.2 The design strategy of Trofarello hospital

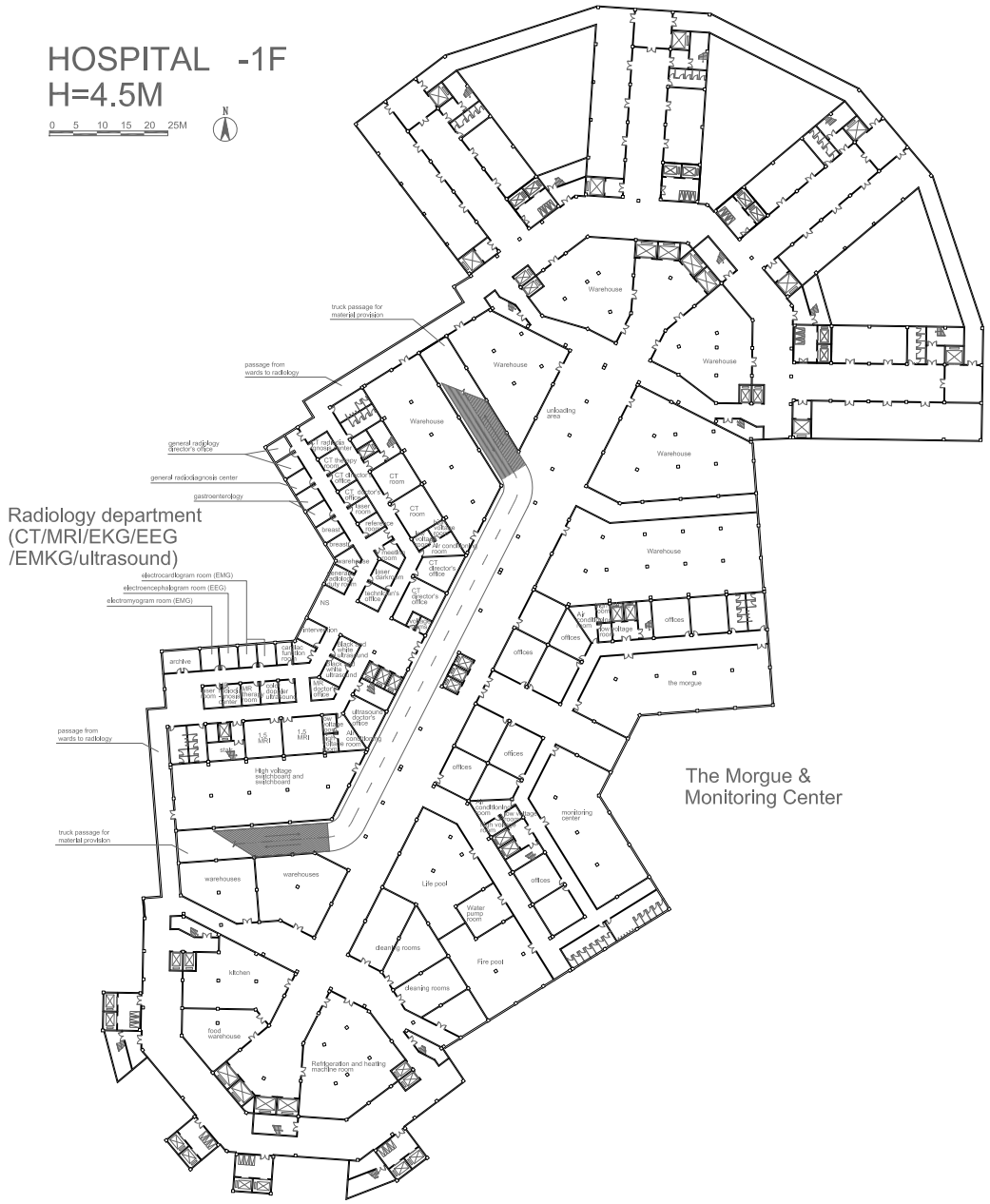
The main entrance of the hospital is on the side of module B near the main road in front of the hospital. The entrance is a two-story hall with an escalator leading directly to the second floor and to areas A, C and D. C, D and ward areas are directly accessible from the groundfloor, and CD is also connected to ward areas. Even if the main access of the hospital is by the AB module, the chance to access directly to the ground floor of the CD module can be useful in case of epidemic. In fair way the hospital can be easily divided into infectious and non infectious. Each partition has corresponding functions, realizing hierarchical traffic organization and spatial arrangement, optimizing the internal streamline and spatial efficiency of the hospital, reducing unnecessary round-trip and mutual interference of patients, and shaping a quiet and efficient environment for diagnosis, treatment and hospitalization.

4.2.1 Underground floor

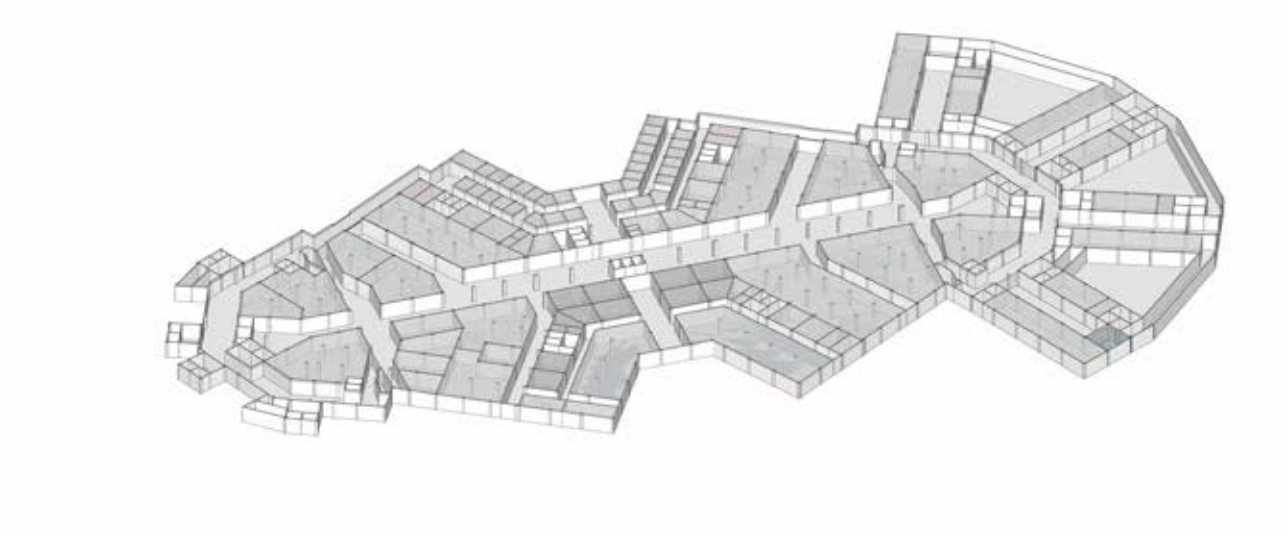
4.2.1.1 Plan

Through the CD area layout change upstairs, instead of in the middle of two elevator into four elevators, all can lead to the downstairs, but to the underground layer of the four elevators for staff use only, for the patients and their families open on both sides of a distribution in the region of the CD, patients from both sides of the elevator down to the underground, have special access to the radiology department, thus solve the patients and staff, even van into a channel problem, achieved the shunt of different people.

Secondly, an elevator leading directly from the ward to the underground level was added. There are two elevators in each ward of each unit that can go straight to the first floor underground, which is the "exclusive elevator" for robots. The robots receive materials from the warehouse on the first floor underground, go through the exclusive channel, and transport the materials to each unit ward through the elevator. The medical waste of the unit ward is transferred to the basement floor and then cleaned out. This not only reduces the manpower of manual transport materials, but also makes the working effect more accurate and reduces work errors.


HOSPITAL -1F
H=4.5M
0 5 10 15 20 25M
N
Radiology department
(CT/MRI/EKG/EEG
/EMKG/ultrasound)
The Morgue &
Monitoring Center
truck passage for material provision
passage from wards to radiology
general radiology director's office
general radiodiagnosis center
gastroenterology
electrocardiogram room (EMG)
electroencephalogram room (EEG)
electromyogram room (EMG)
archive
passage from wards to radiology
truck passage for material provision
Warehouse
unloading area
offices
the morgue
monitoring center
Life pool
Fire pool
Water pump room
cleaning rooms
kitchen
food warehouse
Refrigeration and heating machine room
warehouses
CT room
CT director's office
MRI
ultrasound
High voltage switchboard and switchboard

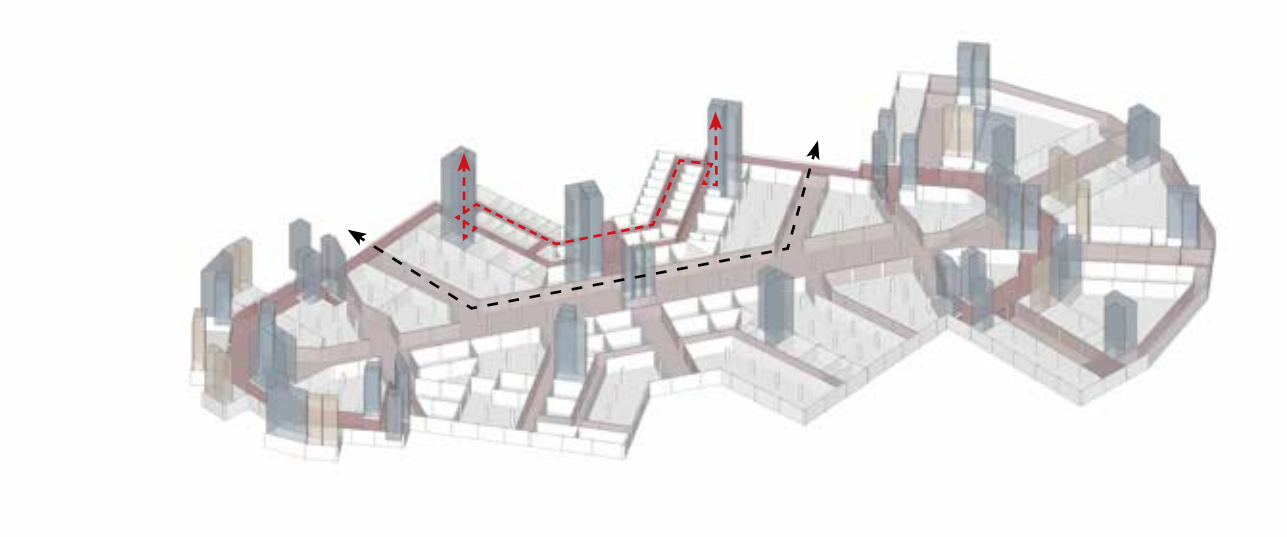
4.2.1.2 Functional partition of the final plan



-1F function analysis

service area
staff working area
supporting facility area
technical area

4.2.1.3 Streamlines in the final plan



-1F streamlines analysis

people vertical streamlines
robots vertical streamlines
outpatient streamlines
patient passage
general staff passage
truck passage for material provision
medical staff and patient in ward/surgery
medical staff passage

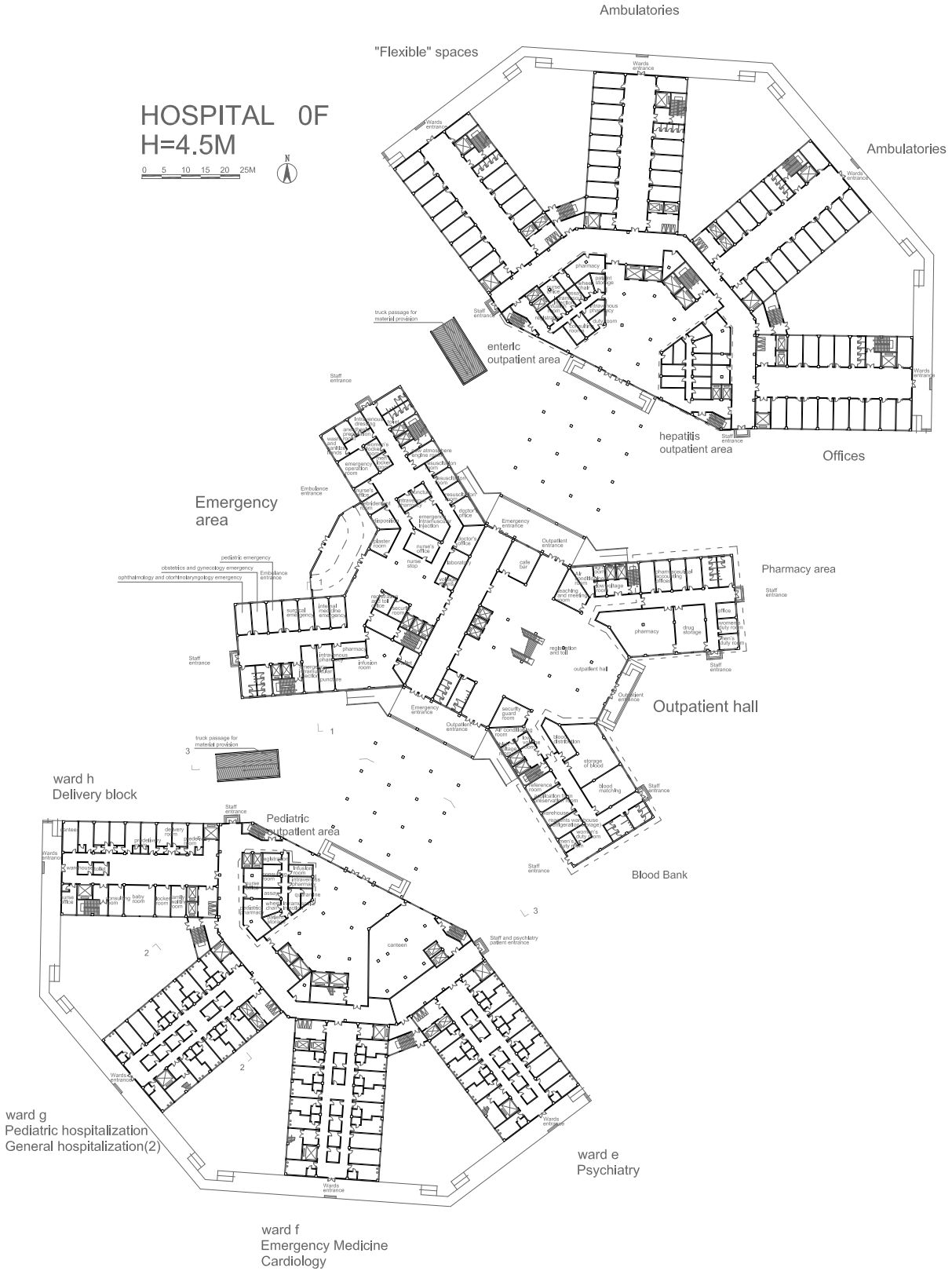
4.2.2 Ground floor

4.2.2.1 Plan

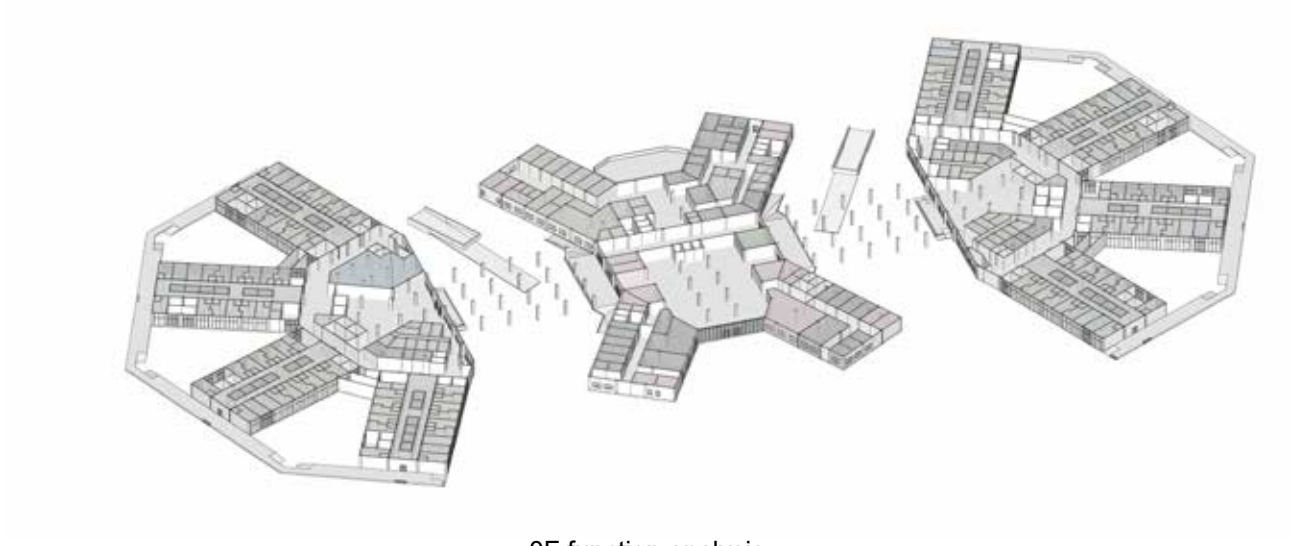
In order to ensure that the ward area can be connected in series, we abandoned the toilet and opened the staff passage to form a whole.In addition, two elevators are set at both ends of the CD area to reach the ground floor. These four elevators are specially for patients and their families to reach the Radiology Department from the wards. The advantages have been shown in the analysis of the subterranean level.

The Emergency department has added the ambulance entrance to facilitate ambulances to send patients directly to the entrance of the Emergency department, and facilitate stretchers or wheelchairs to directly enter the Emergency area. Among Emergency department and the outpatient hall walls and doors, make the Emergency department, and other areas separated, make emergency internal flow and other streams of hospital area do not conflict, increase the efficiency of Emergency department, Emergency department is the hospital that need the most efficiency of the department, to race against time, streams of Emergency department is very important, can't have any crossover and disturb, affect their work efficiency.

The original column net size of the ward was 8mx6mx8m, and a row of rooms for medical staff were added in the middle, which made the two corridors a little crowded. Therefore, we increased it to 8mx8mx8m. As the width of the ward increased, the area of the CD area also increased (because the width of the CD side was determined according to the width of the ward). In the early stage, the C/D area is 4932m2, which is too large, so the lighting and ventilation are very limited.The middle C/D area was 1605.7m2.The final version is 2172.3m2.


HOSPITAL 0F
H=4.5M
0 5 10 15 20 25M
N
Ambulatories
"Flexible" spaces
Ambulatories
truck passage for material provision
enteric outpatient area
hepatitis outpatient area
Offices
Emergency area
Pharmacy area
Outpatient hall
ward h
Delivery block
Pediatric outpatient area
Blood Bank
ward g
Pediatric hospitalization
General hospitalization(2)
ward e
Psychiatry
ward f
Emergency Medicine
Cardiology

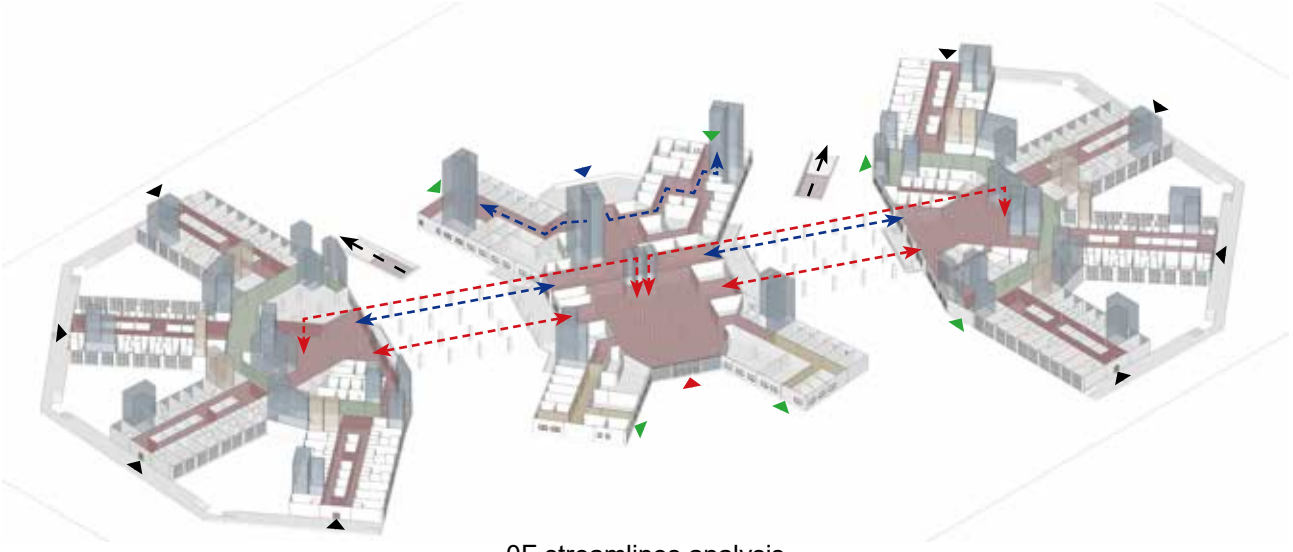
4.2.2.2 Functional partition of the final plan



0F function analysis

service area
staff working area
patient/reception area
technical area
supporting facility area
rest area

4.2.2.3 Streamlines in the final plan



0F streamlines analysis

people vertical streamlines
robots vertical streamlines
outpatient streamlines
outpatient entrance
patient passage
general staff passage
emergency streamlines
emergency entrance
medical staff and patient in ward/surgery
medical staff passage
truck passage for material provision
medical staff entrance
visitor and patient entrance

4.2.3 First floor

4.2.3.1 Plan

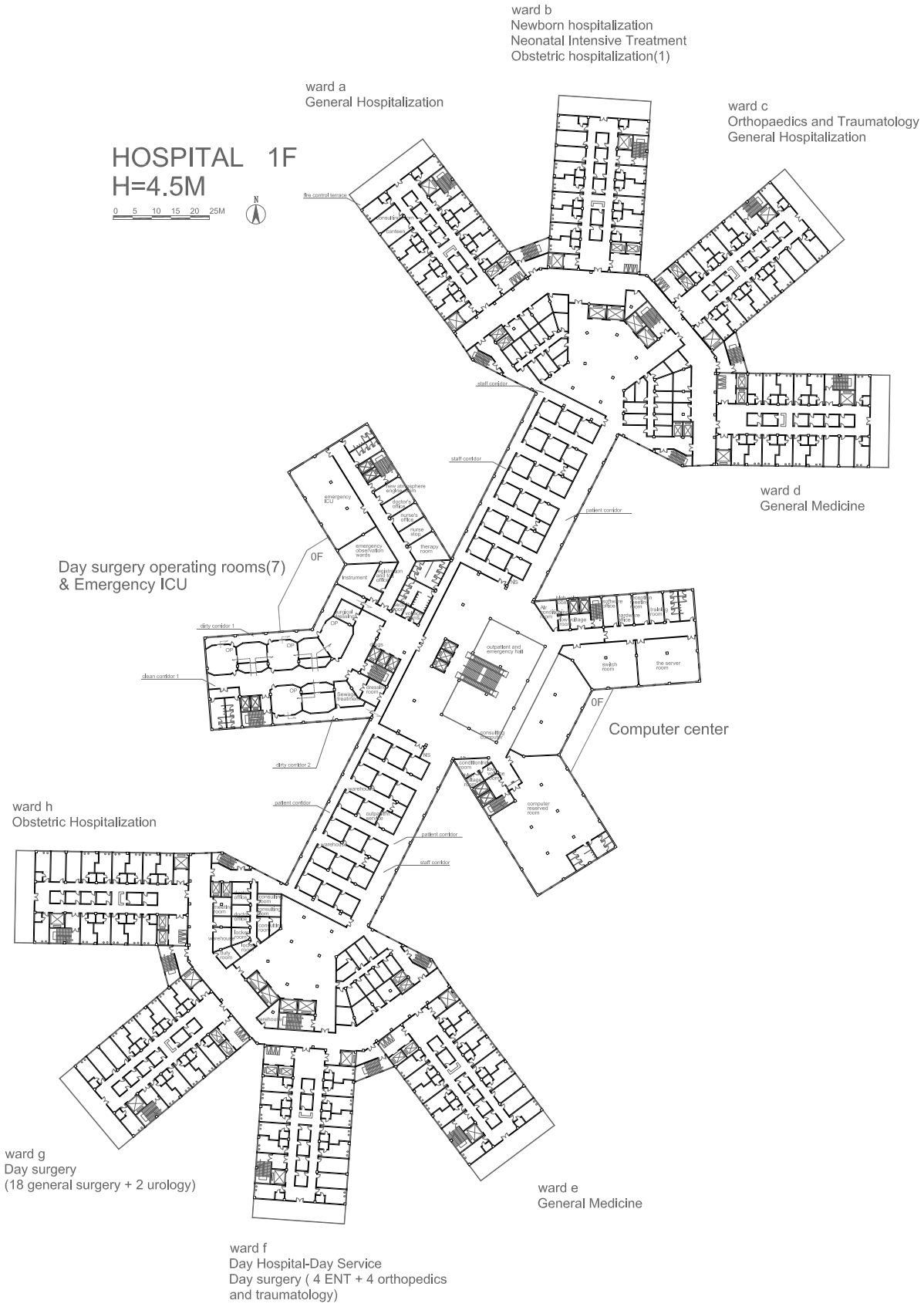
The final version has made a lot of reforms on the basis of the original, as follows:
(1) In order to ensure that the ward area can be connected in series, we abandoned the toilet and opened the staff passage to form a whole. In addition, two elevators are set at both ends of the CD area to reach the ground floor. These four elevators are specially for patients and their families to reach the Radiology Department. The advantages have been shown in the analysis of the subterranean level.

(2) Two-thirds of the rooms in CD area are for medical staff. A row of rooms and corridors are added on the original basis. The corridor is the passage for medical staff to their offices, the room is the consulting room, and the rooms facing the passage to ward are functional rooms for medical staff, such as warehouse, meeting room and duty room.

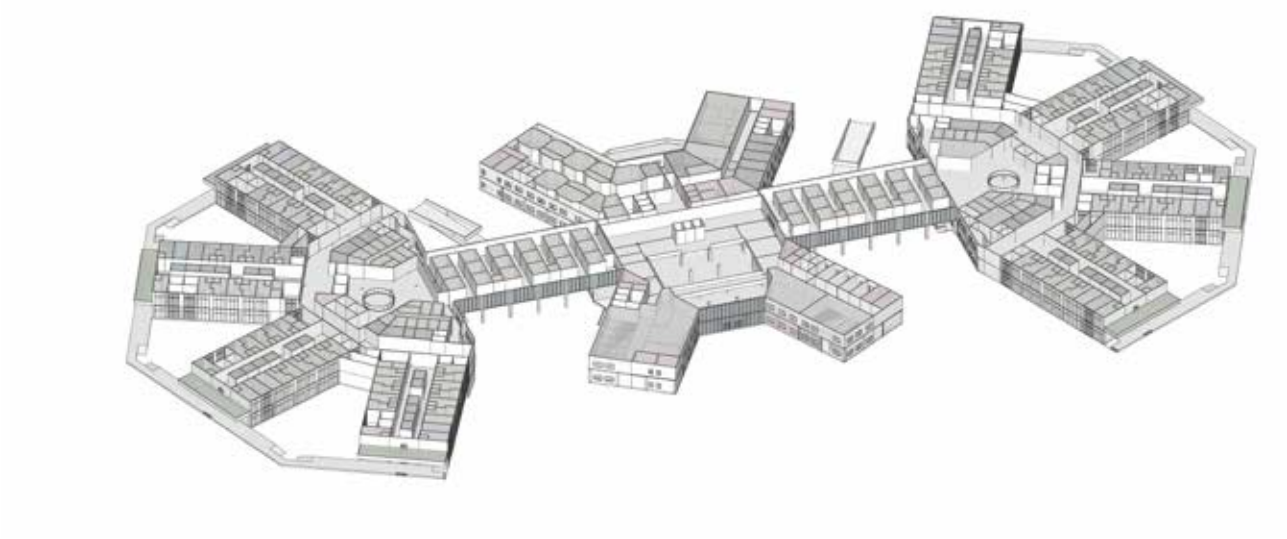
(3) The space on the bridge is divided into five spaces: three corridors and two rows of consulting rooms. In this way, the common corridor on both sides and the staff corridor in the middle can separate the flow lines of medical staff from ordinary patients and their families.

(4) The previous plan did not consider the fire prevention space. Now, a fire control terrace is added at the end of each ward unit. If a fire breaks down, patients in the ward and others trapped in the hospital can temporarily hide on the balcony.

(5) Since there was no channel between operating room and sard in the previous plan version, we added the channel to second floor, which will be explained in the analysis on SecondFloor.


HOSPITAL 1F
H=4.5M
0 5 10 15 20 25M
N
ward a
General Hospitalization
ward b
Newborn hospitalization
Neonatal Intensive Treatment
Obstetric hospitalization(1)
ward c
Orthopaedics and Traumatology
General Hospitalization
ward d
General Medicine
Day surgery operating rooms(7)
& Emergency ICU
0F
Computer center
ward h
Obstetric Hospitalization
ward g
Day surgery
(18 general surgery + 2 urology)
ward e
General Medicine
ward f
Day Hospital-Day Service
Day surgery (4 ENT + 4 orthopedics
and traumatology)

4.2.3.2 Functional partition of the final plan



1F function analysis

service area
staff working area
patient/reception area
technical area
supporting facility area
rest area

4.2.3.3 Streamlines in the final plan

1F streamlines analysis

people vertical streamlines
robots vertical streamlines
outpatient streamlines
patient passage
general staff passage
emergency streamlines
medical staff and patient in ward/surgery
medical staff passage
outpatient entrance
emergency entrance
medical staff entrance
visitor and patient entrance

4.2.4 Second floor

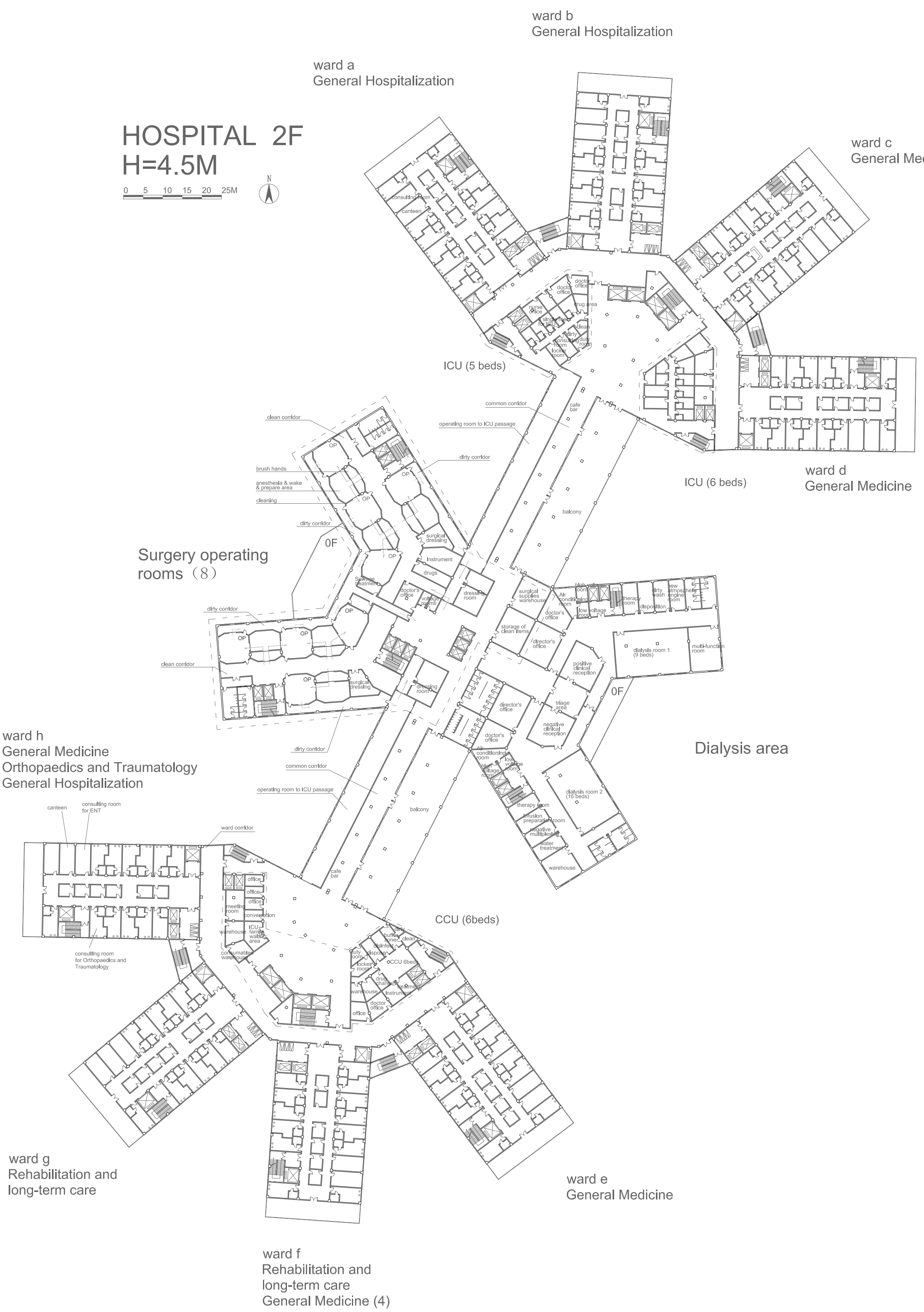
4.2.4.1 Plan

Compared with the previous version, CD area and ward unit have not changed much, mainly bridge and AB area function and streamline.

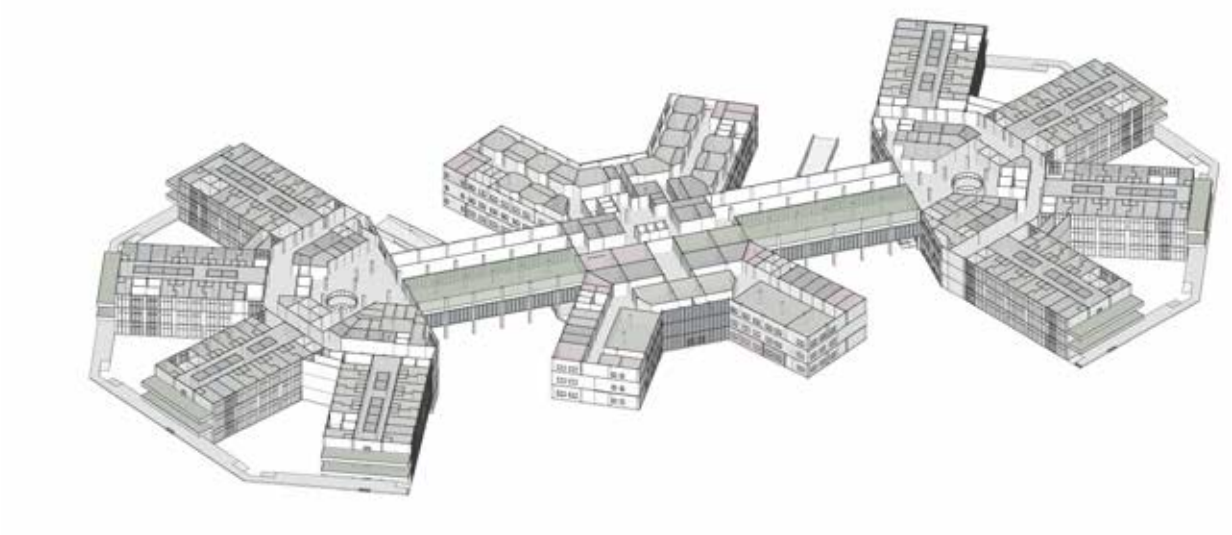
The biggest change has been in the operating room. The surgical unit was changed from a rectangle to an octagon that was nearly round. With two operating rooms as a group, there are three octagons in total, with operating rooms on both sides, and the common area shared by the two operating rooms in the middle: anesthesia&wake&prepare area.The whole A area is divided into five Spaces: three corridors and two rows of operating rooms. Clean corridor in the middle and dirty corridor in the two sides. Each operating room has a door along the clean and dirty corridor. Patients to be operated enter the operating room from the preparation area through the clean corridor, and then they are sent to the ward again from the clean corridor after the operation, while the medical dirt and medical staff generated by the operation walk through the dirty corridor to clean themselves from the cleaning near the operating room. Area A has three entrances and exits: two passageways for patients undergoing surgery, clean corridor; In the middle is a dirty corridor, which is responsible for transporting medical waste and medical workers after surgery. There is waiting space for family members at the gate of area A.

The space on the bridge is divided into two parts: one third is the passage from the operating room to the CD area, and two thirds is the outside yard, where people can rest and entertain. The CD area also provides access to the hospital room.

HOSPITAL 2F
H=4.5M



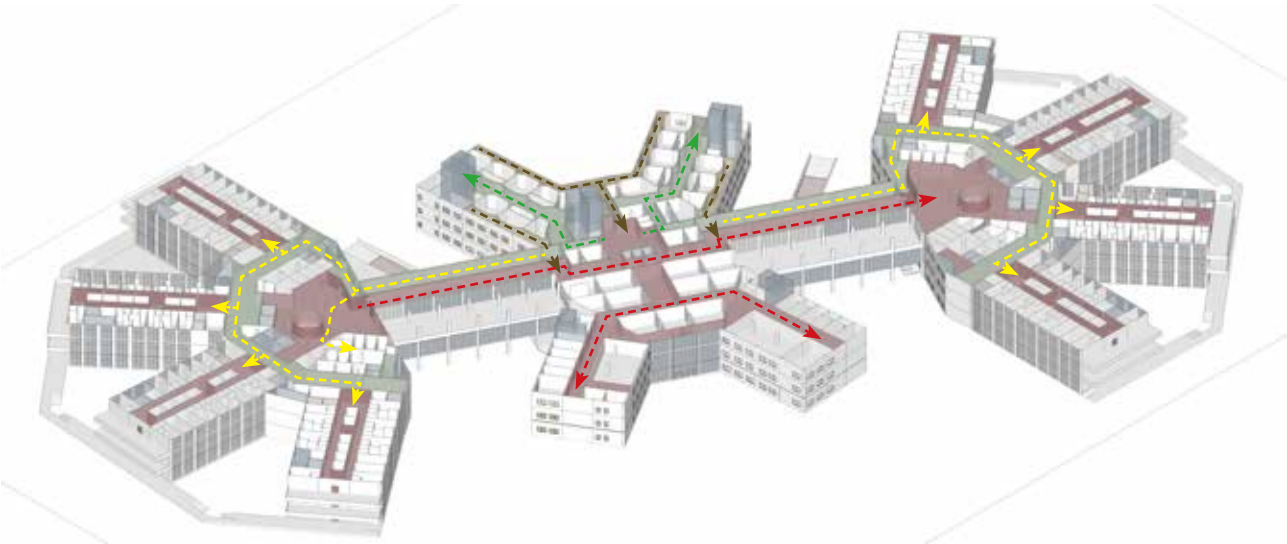
4.2.4.2 Functional partition of the final plan



2F function analysis

service area
staff working area
patient/reception area
technical area
supporting facility area
rest area

4.2.4.3 Streamlines in the final plan



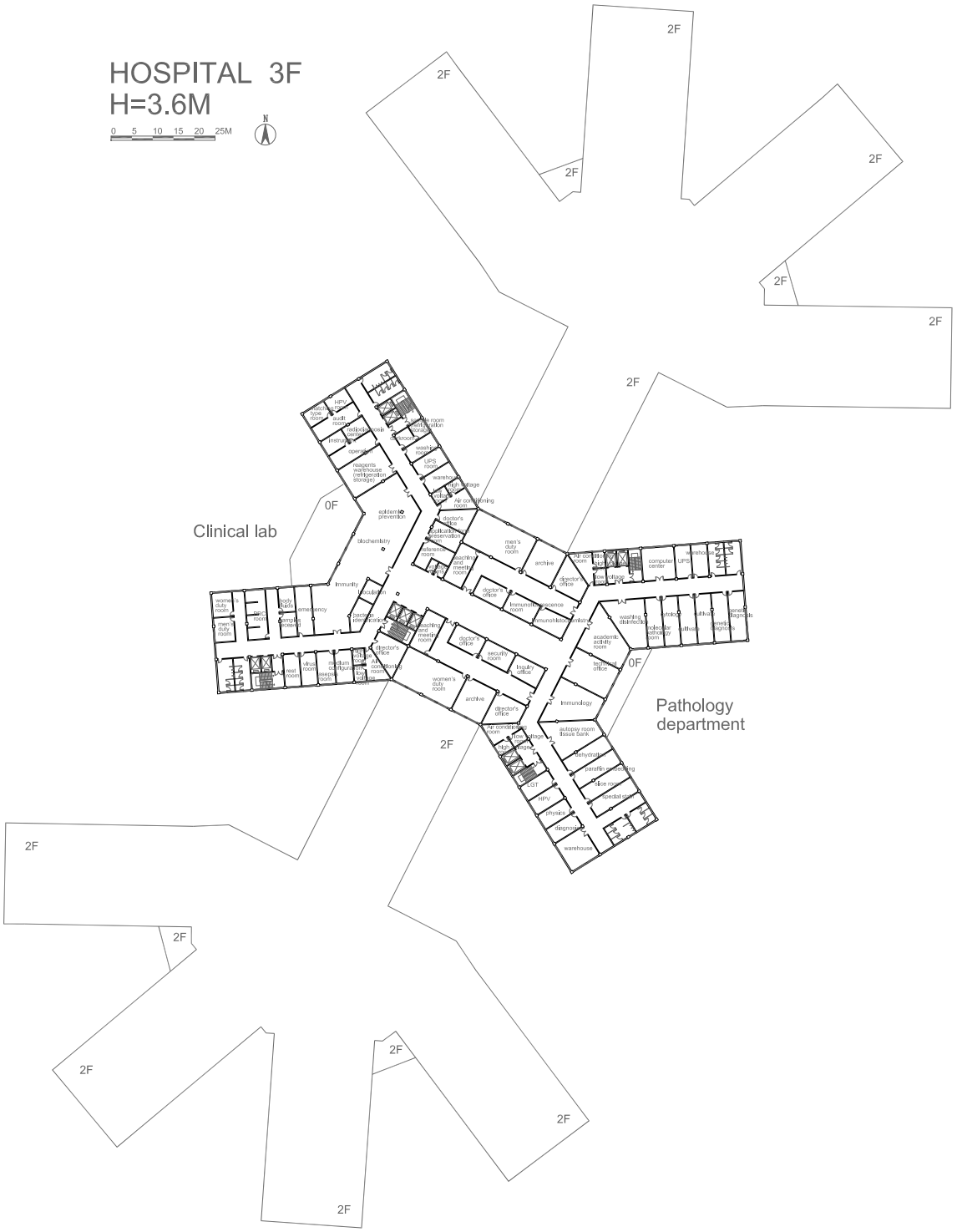
2F streamlines analysis

people vertical streamlines
robots vertical streamlines
outpatient streamlines
surgery clean passage
patient passage
general staff passage
surgery dirty passage
medical staff and patient in ward/surgery
medical staff passage
operating room to ICU/ward passage

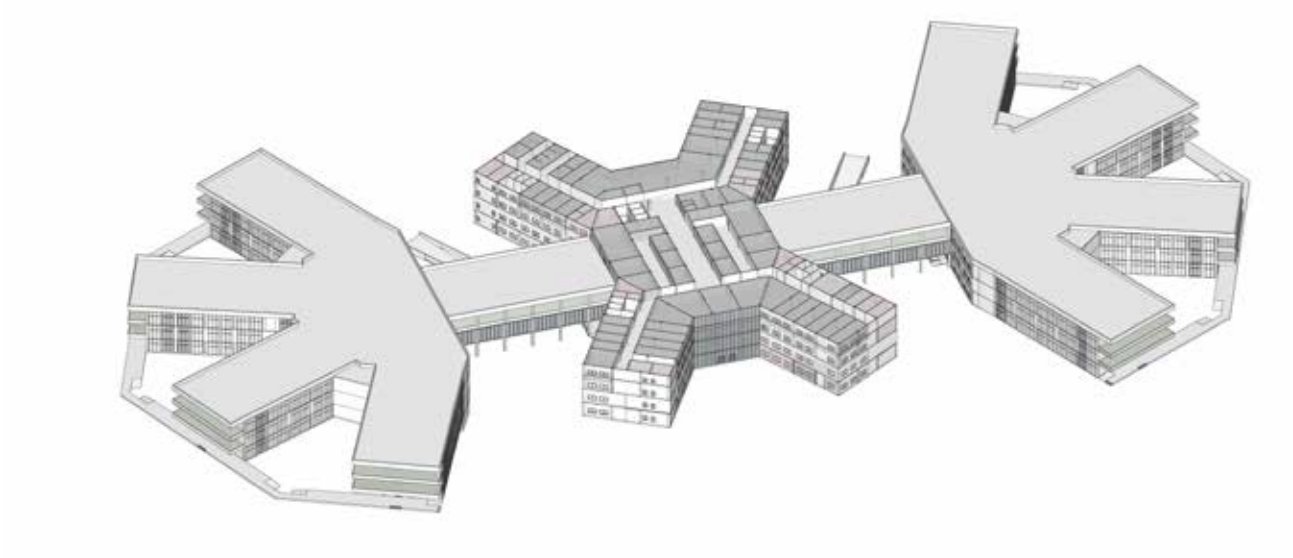
4.2.5 Third floor

4.2.5.1 Plan

After discussion, we changed the Dialysis Area in area A into Clinical Lab in the previous version, and changed the Administrative Office area in area B into Pathology Department. In addition, the connecting gallery in the middle was removed, and AB space was directly connected to form a whole space. This floor and above is only open to hospital staff, so the function was changed.



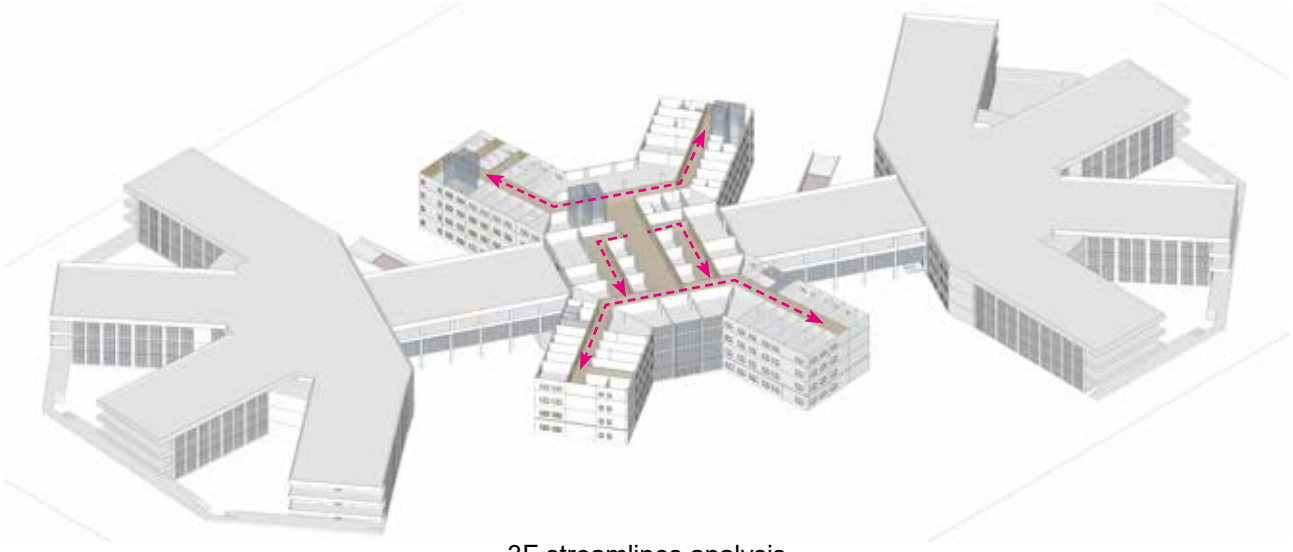
4.2.5.2 Functional partition of the final plan



3F function analysis

service area
staff working area
patient/reception area
supporting facility area

4.2.5.3 Streamlines in the final plan



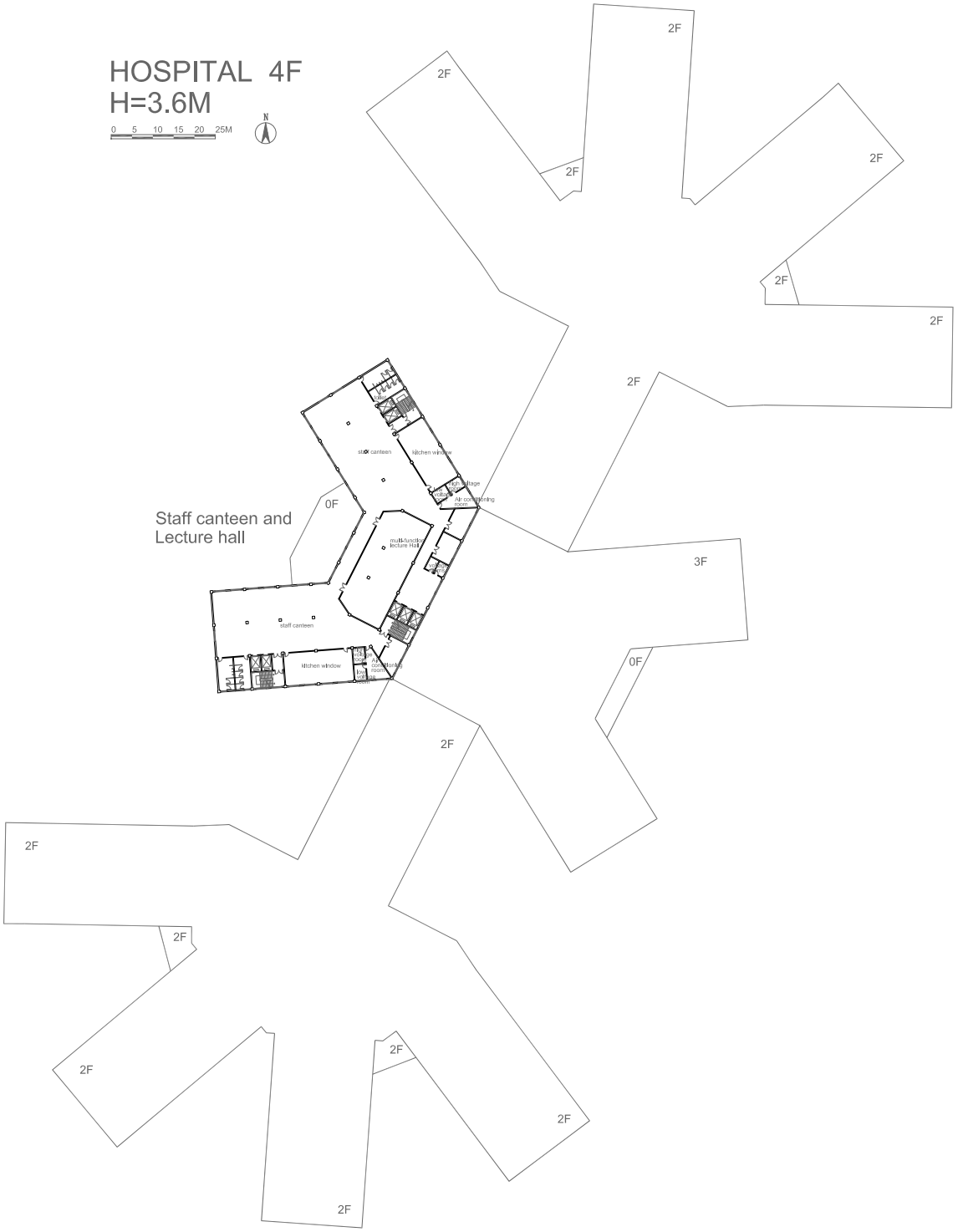
3F streamlines analysis

people vertical streamlines
medical staff passage
medical staff passage

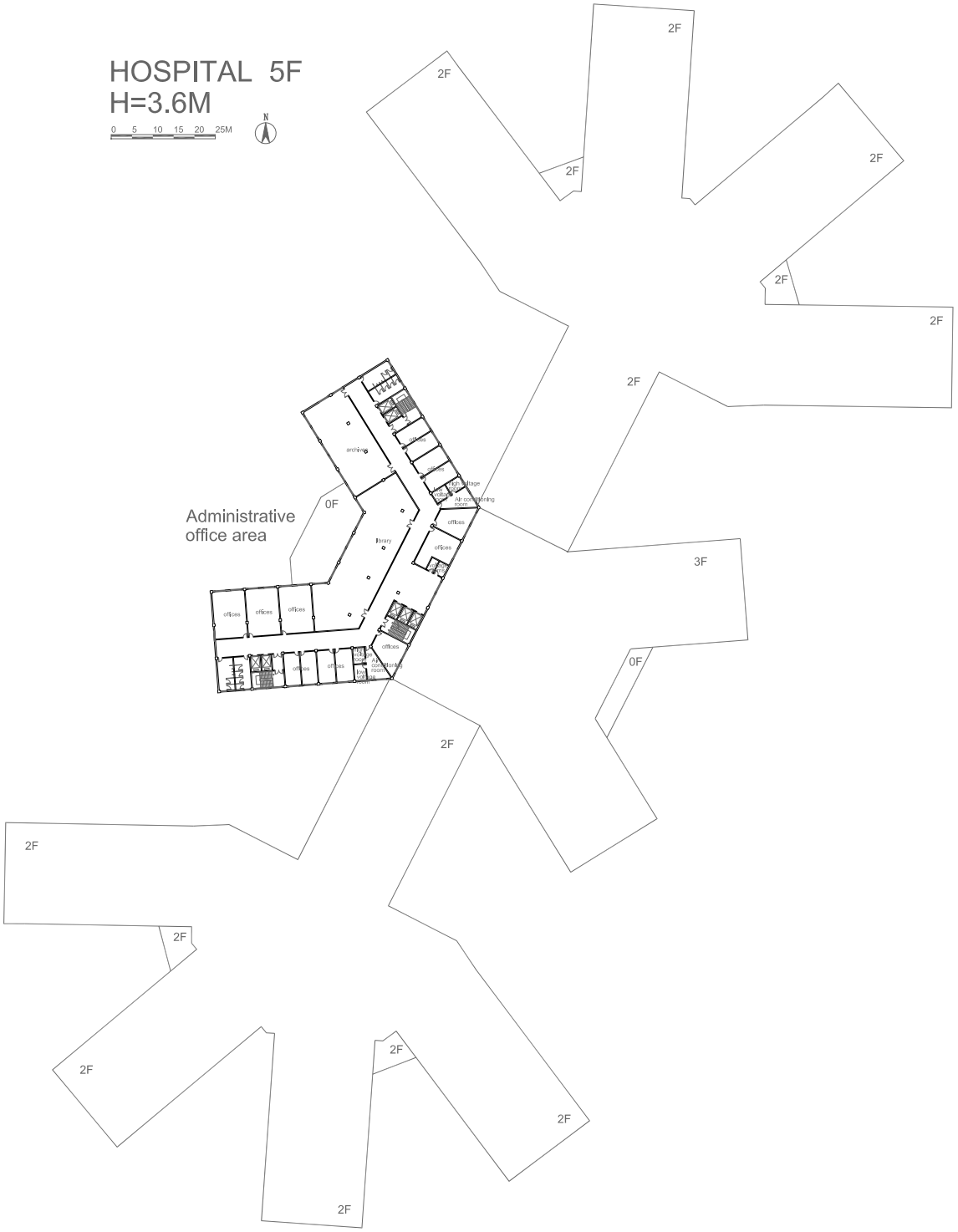
4.2.6 Fourth and fifth floor

4.2.6.1 The deficiency and improvement of the plan in the early and final stage

In the initial version, area A was Clinical Lab and area B was Pathology Department, both of which were reserved for staff. As the function of the previous floor was modified, finally, area A became the staff canteen and lecture hall, and area B became the administrative office area.

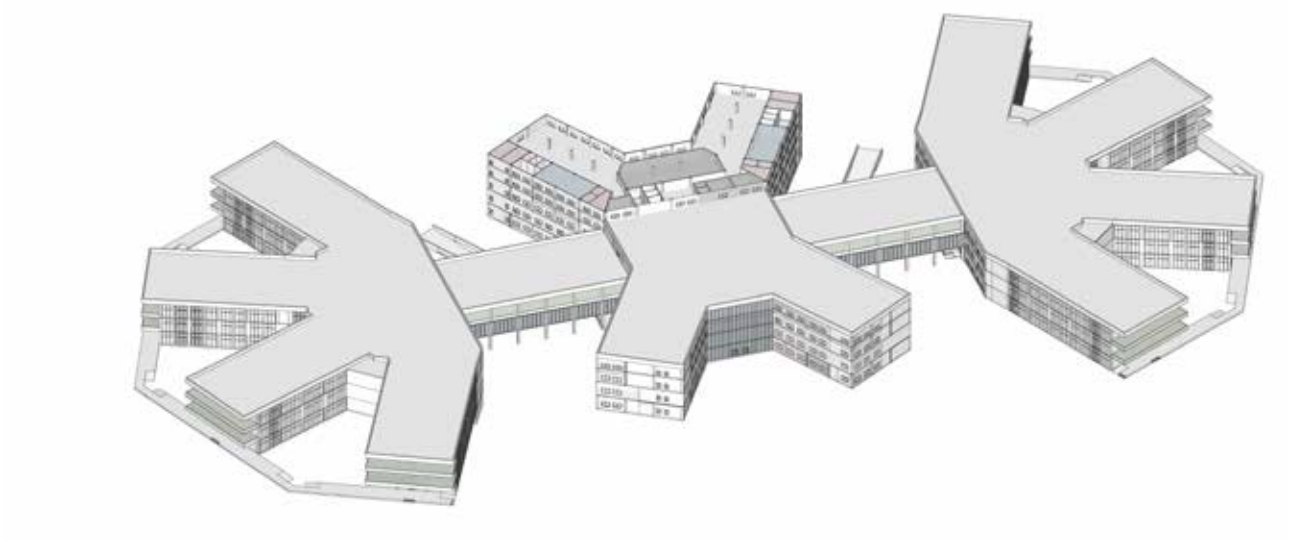


Fourth floor


HOSPITAL 5F
H=3.6M
0 5 10 15 20 25M
N
2F
2F
2F
2F
2F
2F
2F
3F
0F
0F
2F
2F
2F
2F
2F
2F
2F
Administrative
office area
archives
offices
offices
High voltage room
Air conditioning room
offices
offices
library
offices
offices
offices
offices
offices
offices
offices
offices
Air conditioning room
Machine room

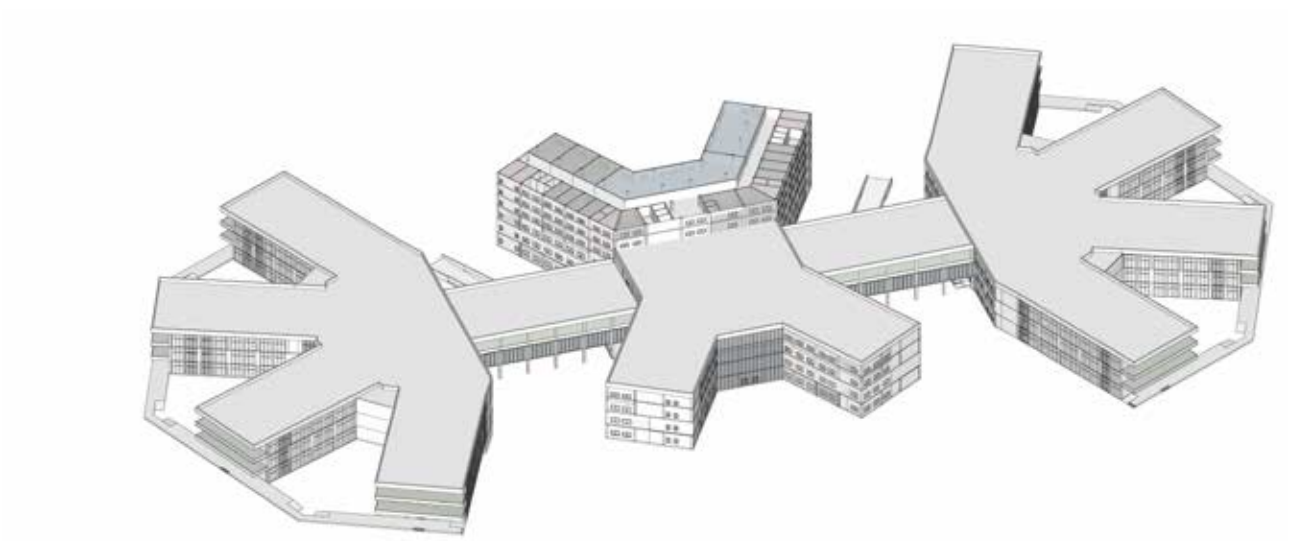
Fifth floor

4.2.6.2 Functional partition of the final plan



4F function analysis

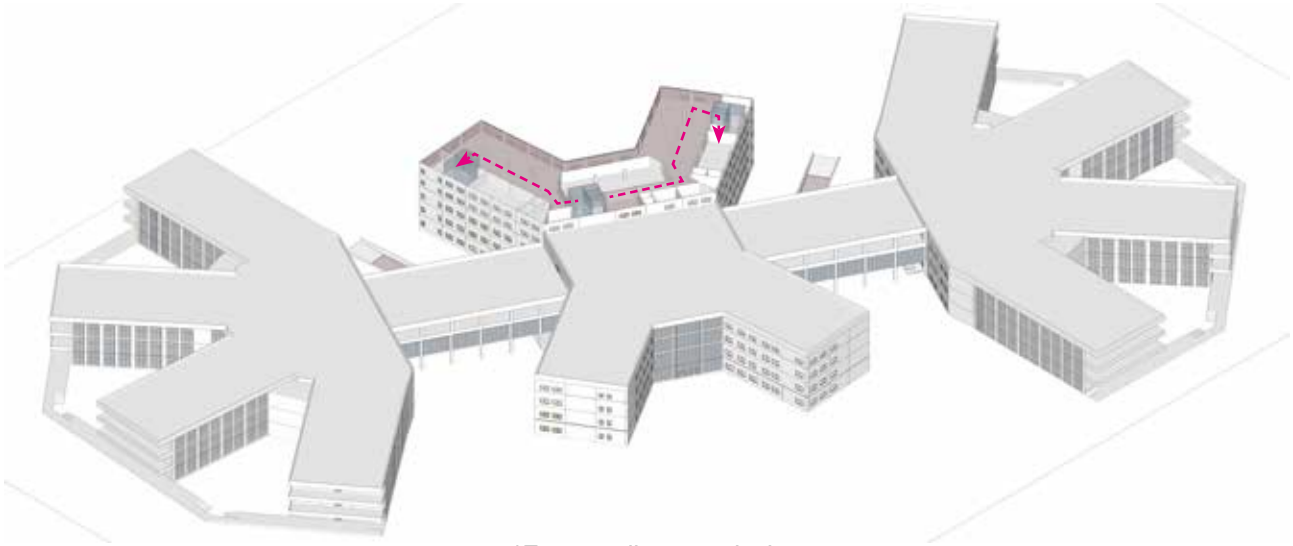
service area
staff working area
patient/reception area
supporting facility area



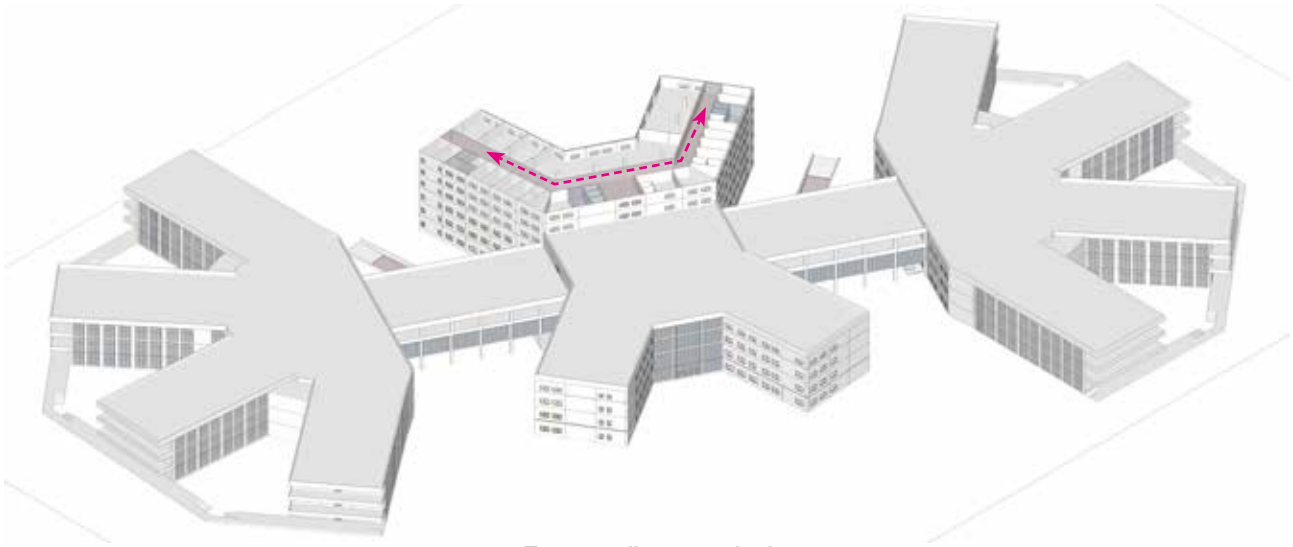
5F function analysis

service area
staff working area
patient/reception area
supporting facility area

4.2.6.3 Streamlines in the final plan



4F streamlines analysis



5F streamlines analysis

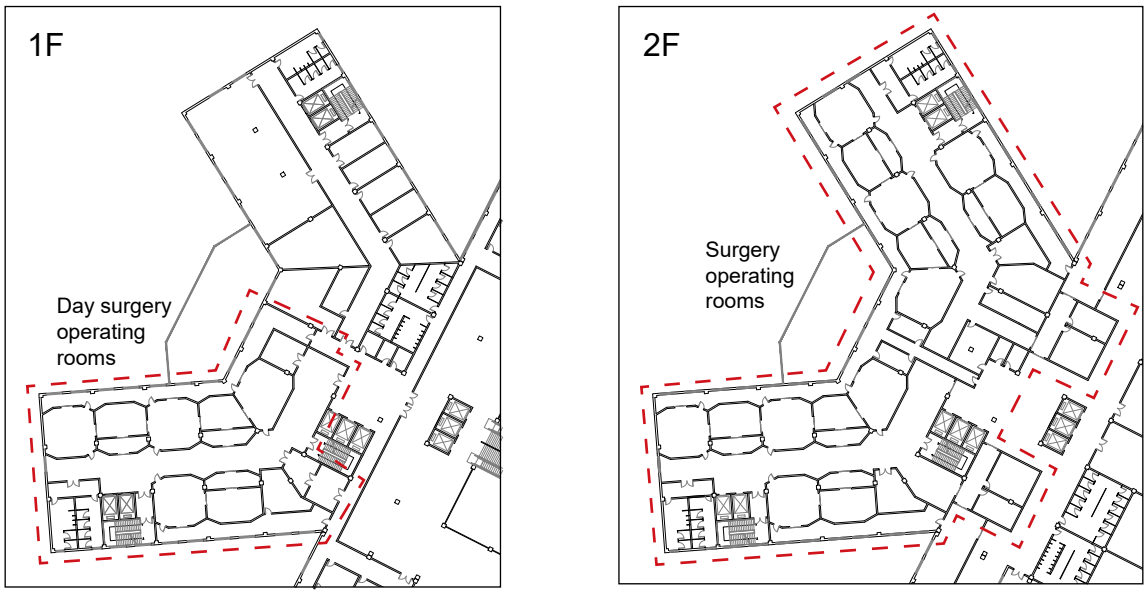
people vertical streamlines

general staff passage

medical staff passage

4.3 The design strategy of each department in Trofarello hospital

4.3.1 Surgical department



The clean operation department is a comprehensive department with complex technology and high cleanliness. For many years, the research of architectural system design principles has been the direction and focus of architects' research. According to the summary in section 4.4.5, our design plan for the surgical department specifically includes the following points (corresponding to section 4.4.5) :

(1) To meet the requirements of medical simplification in clean surgery.
Because the medical streamline inside the cleaning surgery department is the original requirement and foundation of this design, its existence stipulates the medical behavior pattern and plane layout principle in the cleaning surgery. The internal medical flow lines are finally concentrated in the clean operating room, and there are four flow lines in and out of the clean operating room. Two exit and exit from the prepare area, one leading to dirty corridor and one leading to clean corridor.

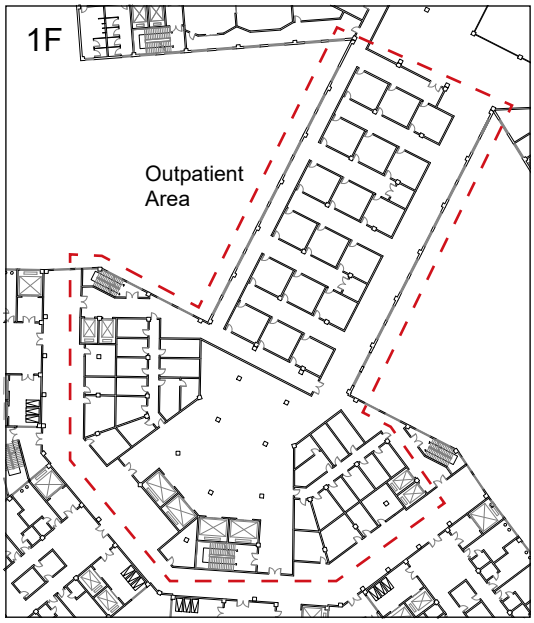
(2) To meet the requirements of infection control.
The clean surgery department is completely separated from other departments of the hospital, leaving only three channels to reach the surgery department: two are for patients undergoing surgery to enter the surgery department, patients and medical staff first through the first door, and then there are medical staff to prepare and change clothes room, and then through the second door to enter the surgery department; Another is linked to the dirty corridor to dump medical waste from operating rooms out of hospitals. Through the control of personnel and flow line, the infection control requirements of clean operation department are met.

(3) The space size of each functional room building module of the clean operation department can be satisfied.
From human activities and equipment put two aspects comprehensive influence, we determine the operation department each room building blocks the internal space scale, at the same time in order to reduce the construction difficulty, we unified the operating room and prepare area of space dimension, column grid structure of the general hospital,

octagonal operating room and prepare the size of the area are 8 mx8m, the space required for the work area is enough.

operating room department

4.3.2 Outpatient department



-Outpatient department
The outpatient department of our hospital serves for general outpatient. The general outpatient service can be divided into appointment outpatient service and non-appointment outpatient service according to the condition of the hospital. Outpatient appointment system can avoid the attention of many outpatient patients, shorten the waiting time and reduce congestion. Hospitals in European countries pay more attention to appointment. At present, most patients in China make post-diagnosis appointment, that is, when the doctor thinks it is necessary for the patient to return to the hospital, he/she is told to go through the next appointment procedures immediately before leaving the hospital, and can also make an appointment by telephone or by the primary clinic on behalf of the appointment. General outpatient consultation is carried out within the prescribed time. Some hospitals promise to carry out consultation on holidays and weekends as usual, and extend the consultation time in the peak period of outpatient consultation to facilitate patients.The general outpatient department of this hospital is set in the CD module and bridge on the first floor, and there are different outpatient departments, such as the clinical departments of medicine and surgery, etc. Radiology department is required for radiation examination, and pharmacy is required to go to the pharmacy on the groundfloor. The general out-patient is the main body of out-patient service, whose out-patient person-time and the area occupy the larger proportion, as well as the distribution and research of medicines.

Outpatient building space can be divided into two types of space: dedicated functional space and public space:
Exclusive functional space: This space is not open to the public and is used by patients for diagnosis and treatment or doctors.The patient receives the diagnosis and treatment space is the consultation room, the treatment, changes the dressing room and so on.The exclusive space realizes the contact between doctors and patients through the consulting room, treatment room, dressing change room, etc., but it is also the exclusive space of doctors' office and doctors' working area, mainly for the work, study, communication, activities and rest space of doctors, nurses and other staff.

Public space: Public space has a certain openness, which is to provide the public with an open place for social activities, rather than a space restricted to people.The public space of a general hospital is an open space that focuses on medical treatment and takes care of relevant people, including the square in front of the clinic, the lounge, waiting room, transportation, communication, courtyard, public service space, etc.

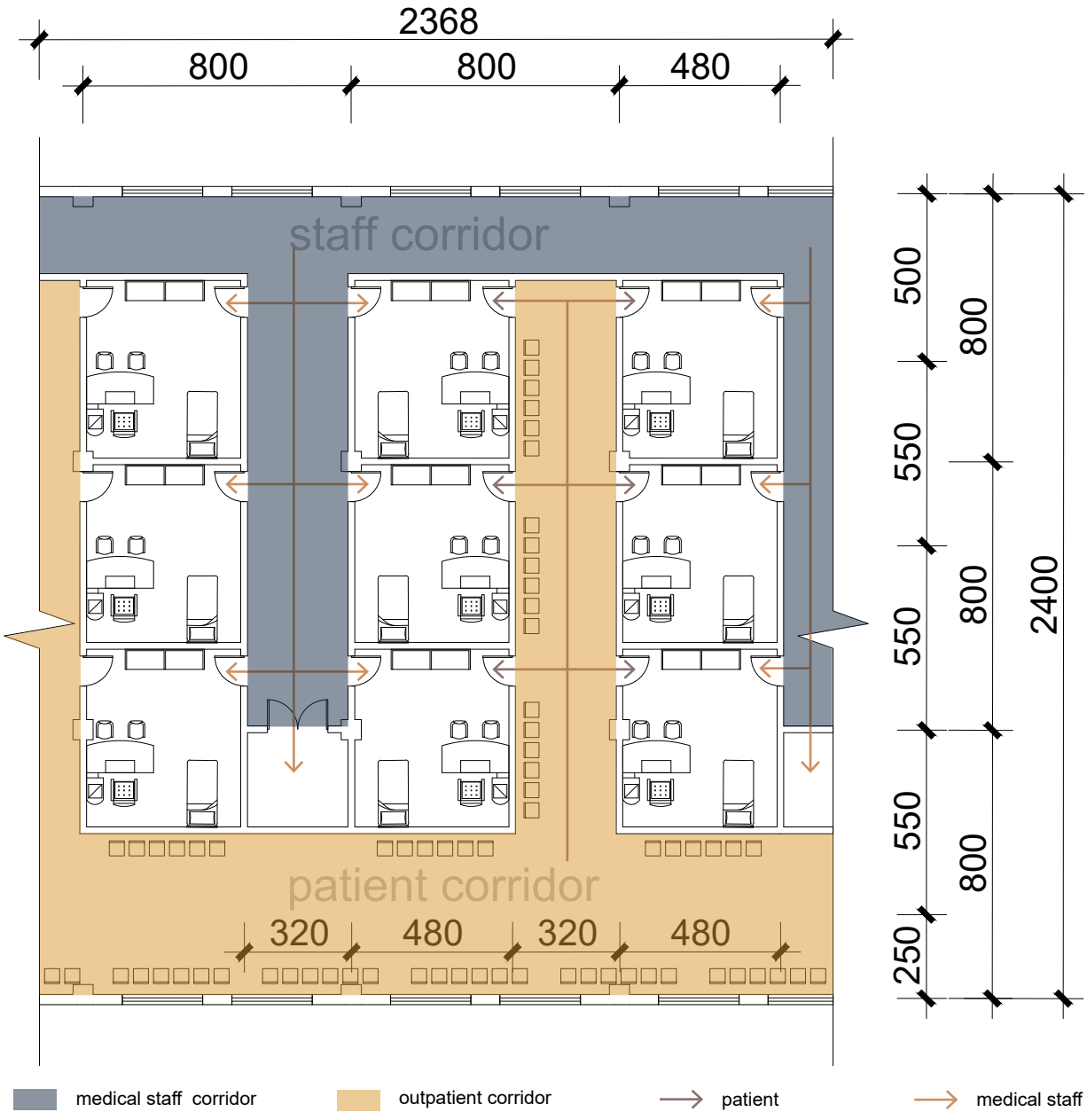
The general out-patient is the main body of out-patient service, whose out-patient person-time and the area occupy the larger proportion.The clinic hall is spacious and bright, and the Courtyard is set in the center. The large C and D modules enable the internal lighting,

and people can also see the landscape of the inner courtyard, which makes them happy.

According to the analysis in section 4.5.4, we design the Outpatient Department as follows (implementation of the design techniques proposed in section 4.5.4):
(1) Design of waiting space
People's waiting behavior can be divided into two ways: linear waiting and centralized waiting. Our project has decided to use both ways.

At the CD area we use the centralized waiting because of its large waiting hall with the beautiful landscape at the center; In the bridge we choose the linear waiting, because the bridge is a long rectangle, which space is suitable for the linear waiting, and also has its advantage of streamlines in order to separate different users.

(2) Design of rest and communication space
In the linear waiting, the rest and communication space are set along with the bridge side;



outpatient department 1:200

In centralized waiting, the rest space are waiting hall. Both of them has enough space to let patients and their family members talk secretly.

(3) Traffic space design
Horizontal traffic: The outpatient department are all concentrated at the bridge and CD area in the first floor, which shortening the length of horizontal traffic, increasing people's walking accessibility and mobility efficiency. Secondly, we achived traffic microcirculation, especially around departments with relatively large visits in the outpatient department, which can induce rapid evacuation of people flow and relieve traffic pressure in the hospital street.

Vertical traffic: Vertical traffic in public space is mainly divided into stairs, escalators and elevators.The escalator was combined with the design of lobby and atrium space to provide the users with a broad vision and good light. Patients and their family members can take escalator from ground floor to get in the first floor, and then turn left or right to get in the outpatient department.

C(D) area have 8 elevators and 1 stair, at the center of the area, the 4 elevators can go down directly to the underground floor but only serve for medical staff. The other 4 elevators where set on the two sides can also down to the underground, but they are serve for patients who want to go to the radiology department, and these 4 elevators are nearlier compare to the center of 4 elevators. These 8 elevators can go to anywhere in the hospital.
(4) Lingering space design
We will use some corners to set the coffee and food machine, and put some desks and chairs that become to the rest space for both medical staff and patients, also their family members.

The home in the consulting room has an outpatient desk, chair and computer. Behind the doctor is a bed for diagnosis and treatment and a cabinet for storing things. This is the most commonly used furniture in the general office.

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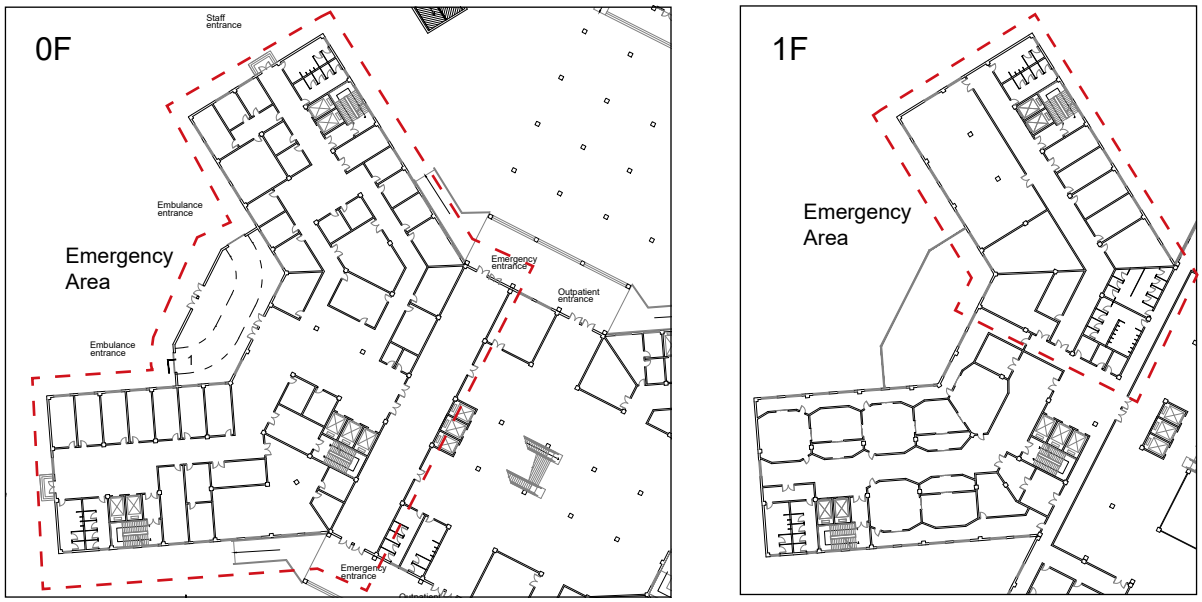
4.3.3 Emergency department



- Emergency area
The emergency department, also known as the emergency department, is an independent department with the highest concentration of patients, the most critical and critical conditions, the most kinds of rescue tasks and the most serious ones.In saving the life of the patient, the first line of dealing with all kinds of critically ill patients is the emergency department, all the emergency patients have to go to the emergency department for hospitalization. Therefore, the overall work of the hospital is concentrated on the work of the emergency department, which reflects the efficiency of the hospital emergency treatment and the quality and level of the work of the medical staff.Modern emergency medicine has gradually developed into an emergency medical center and emergency medical research center integrating first aid, first aid and intensive care, providing one-stop first aid services to critically ill patients.

The emergency department is a department in the outpatient department, which is divided into internal medicine, surgery, pediatrics and other specialized consulting rooms, as well as observation rooms and operating rooms.The medical and surgical staff are relatively fixed and equipped, so they need the support of other departments.In our hospital, there are emergency operation room, debridement room, resuscitation room, treatment, emergency intramuscular injection, plaster room, puncture, infusion room, internal medicine emergency, surgical emergency, obstetrics and gynecology emergency, and pediatric emergency etc., and also have supplementary rooms for emergency operation room-wash and sanitize hands, anesthesia preparation room, intravenous dressing, locker room; and some supplementary rooms in the emergency area such as doctor office, nurse

office, laboratoty, disposition, registration and toll office, security room, pharmacy and toilet.

The emergency department shares the resources of the outpatient department and the medical technology department, and its business level is relatively high, so it bears the task of emergency treatment in the city.

Based on the analysis of the efficiency of the emergency department in section 4.6, our thinking and design for the emergency department are as follows:
-Layout optimization - partition build
The hospital's various functions leave an impression of either the smell of disinfectant water or the bewildering labyrinth of space.Lead to the chaos of the hospital at the same time also increases the probability of cross infection of the flow of people, bringing a lot of troubles to the patients. Only reasonable arrangement of each functional space in the emergency department and clear traffic streamline design can optimize the combination of functional space, make the treatment of patients reach the best degree in the shortest time, and eliminate the tension of the accompanying family members. Therefore, consider the following settings:
(1) Provide unobtrusive and convenient access to the emergency department.
We set up the ambulance-entrance outside the entrance of the emergency department. In order to facilitate the transport of patients by ambulances, the beds were directly carried down and quickly moved into the emergency department.

We also set up the ambulance-entrance outside the entrance of the emergency department. In order to facilitate the transport of patients by ambulances, the beds were directly carried down and quickly moved into the emergency department.

And a separate access is also provided in the side of the buildings,such access can be split in two in case of epidemics.

The road in front of the emergency department is specially set up for the emergency department. Only ambulances and trucks can pass, but only ambulances can stop in front of the emergency department. The road of the emergency department leads directly to the city and the railway station, which is convenient for transportation. Ambulances can also be parked beside the emergency department directly without affecting the passage of other vehicles, and there is a dedicated ambulance parking space.

Emergency department triage in the hall is located in the emergency department, emergency exit location in the middle and face them, when patients into the hall, the nurse understand condition after timely treatment work arrangement, near the elevator hall at the same time, all aspects of the emergency rescue system to form a organic whole, facilitate timely give play to the role of the emergency first aid, improve the quality of rescue.

(2) Integration of hub space, clear guidance signs.
The emergency hall at the entrance, as a comprehensive functional space, is the starting point of the whole medical process and the transportation hub leading to each functional department. Therefore, the space should be simple and clear, easy for patients to flow, easy to judge the direction they want to go, and can provide a variety of medical information.
(3) Design efficient functional modules.

The functions of different departments in hospitals are not the same, and the space size and layout have their own characteristics. It often closely related departments with similar functional properties and similar spatial size are organized together to form functional blocks, and then they are linked together by horizontal or vertical traffic. Emergency department is a department with complex functions in a general hospital, including all departments and departments of the hospital, with a large and concentrated flow of people, and close connections among functional departments and departments.

The emergency department is generally located on the first floor, with a rescue room, debridement room, operating room, observation room, emergency consulting room, intensive care unit, emergency pharmacy, etc. The functional design of the building is complete, reflecting the characteristics of centralized, efficient and convenient management. In order to facilitate the efficiency study, the building functions of the emergency department are divided into four functional modules, which are the public part (hall, registration fee, medicine collection, waiting, elevator hall), the emergency part (diagnosis, treatment, infusion, injection), the emergency part (rescue, operation, disposal), and the observation part (observation, ward, EICU). Different module combinations are adopted for different types of functions, so as to properly design the use function of space and improve the use efficiency of space.

① Public space

Including public transport space, emergency emergency hall, registration office, pharmacy and other public departments, mainly for the use of patients and escorts, generally arranged near the entrance, convenient transportation.As the hub of the traffic space, the emergency hall is arranged in an open style with simple functions. It only arranges triage, registration, charging, taking medicine, etc., and also sets up stairs, vertical elevators and other traffic organizations to solve the problem of large traffic demand in the emergency department and thus improve traffic efficiency.As a transportation hub, patients have to go through the hall to other departments, which can effectively divert patients and prevent traffic congestion.Therefore, we arranged the triage desk, registration fee, pharmacy and vertical traffic together to form a functional module, and organized the traffic flow with the comprehensive hall as the center.

② Emergency part

It mainly deals with ordinary emergency patients.Including each department consultation room and its affiliated waiting space, infusion room, injection room, treatment room. The corridor is used to organize the flow of people to form a diagnosis and treatment module.

③ Part under observation

It mainly includes three parts: hospitalization, emergency ward and intensive care, which can form a functional module and is generally close to the emergency area.The setting of observation beds should be determined according to the number of emergency patients and the characteristics and tasks of various specialties. The use of emergency observation beds can reduce the time of patients staying in the emergency room, make rational use of medical resources, and effectively distribute the flow. The critical patients are also convenient to contact with the operating room and emergency ICU for timely treatment of the disease.

④ First-aid part

It is the location function module of triage table, rescue room and operating room. Triage is the first step in the medical process. It is usually placed in the most prominent place at the

entrance and can be seen by patients as soon as they enter the emergency department. The triage table is the forefront of the medical process in the emergency department. Nurses receiving patients quickly make triage by inquiring the medical history. For example, patients with life-threatening poisoning and other diseases will be sent to the emergency room immediately, while patients with more traumatic bleeding will be directly sent to the operating room. The other part is the traffic space and waiting space.

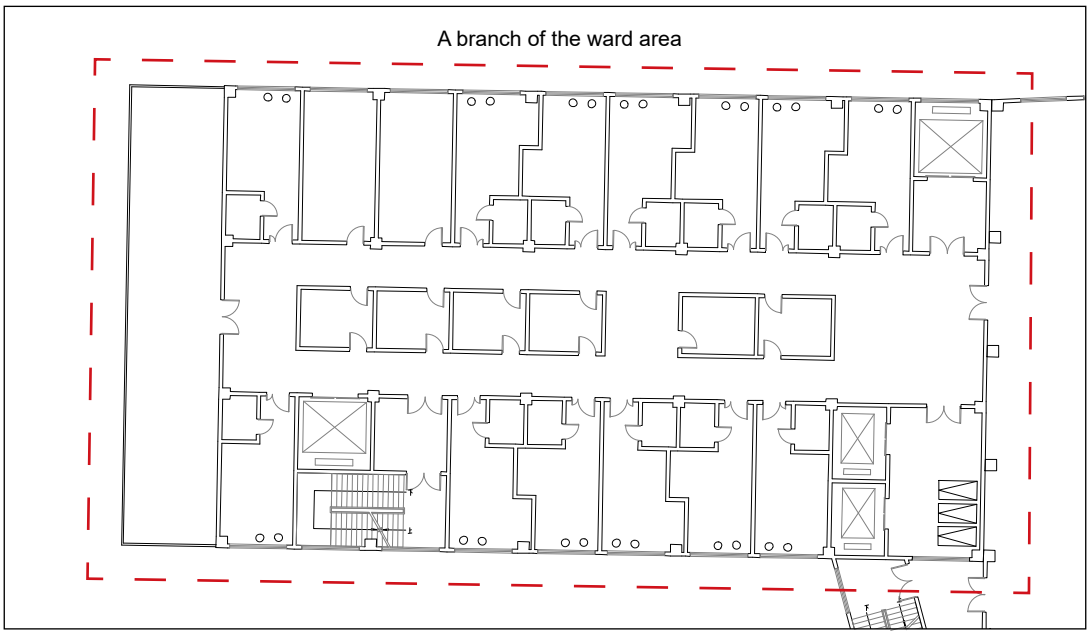
-Process improvement - reengineering integration
Process, see a doctor, examination, treatment is one of the most important service part and low efficiency of situation will appear in the registered, the price you pay, queuing, inspection, repeated queuing, the hospital formalities, waiting, take medicine in the process of this a few, therefore to improve efficiency, must ensure the normal operation of the main link, simplify the other process. Simply put, it starts from the current process, removes inefficient links, integrates repeated steps and reduces processes that waste time, increases overall coherence to achieve the purpose of process optimization, and improves management efficiency through network technology.

According to the previous analysis, patients in the emergency department are eventually transferred to various specialties, inpatient departments, or discharged directly. Therefore, to improve the efficiency of the emergency department, it is necessary to ensure that the exit of the emergency department is unblocked to prevent patients from being stuck in the emergency department and reduce the turnover rate. In addition, patients often use the testing, X-ray and other examination functions of the medical department, thus occupying relevant resources, which can be considered as a priority for the emergency department to shorten the hospitalization time.In order to reduce unnecessary links, process optimization methods can be summarized as follows:
(1) Achieve cross-post collaboration
Responsible for the first diagnosis, triage treatment. The main task of the triage desk in the entrance hall is to carry out the transport of critical patients and the handover before hospital, so as to ensure the timely arrival of medical staff. In addition, if the vital signs of the critically ill patients are stable, they will be sent to the critical critical treatment area, and the medical and nursing staff can treat them on the ground, effectively shortening the transportation distance. Namely, the ambulance on the ambulance and the hospital triage desk staff and the rescue of the medical staff to achieve seamless connection, successfully complete the emergency patients from transport to triage and then to the treatment of a series of links of treatment, there is no shift of responsibility waiting can not be timely rescue phenomenon.

(2) Simplify the process of medical treatment and implement partition management
For a long time, in the medical process, the first step for patients to seek medical treatment is to register, from waiting in line to the patient to the staff to explain or ask their own registration category and medical department information, at least about 3 minutes of time, if in the holidays, evening and other peak hours, there will be a longer queue time.Over-complicated medical procedures reflect the low efficiency of hospitals, which not only causes unnecessary pain to patients, but also increases the time that patients stay in the hospital. The procedure setting of the emergency department in many hospitals is not appropriate. Patients are waiting together regardless of whether the condition is urgent or not, which often results in the delay of the emergency treatment.Common emergency patients and patients in urgent need of rescue are mixed, easy to cause cross infection.
Therefore, according to the severity of the disease, the medical procedures of patients can

be divided into two categories: emergency and first aid, and even three categories: general emergency and emergency and critical. Using the normal registration procedure in patients with emergency start medical treatment process, is the first aid for emergency and critical patients skip this link, with direct access to the intensive care or clinic for rescue and treatment, and then the way to pay the registration fee, will solve the emergency patients in urgent need of the contradiction between rescue and registered to delay treatment time, convenient for the critical patients, save time, simplify the process. In other words, the triage zoning management of critical, urgent and general urgent patients is the key to emergency work.

4.3.4 Ward area



- Ward area

The ward area is located in the north and south of the hospital matrix, and from the first ward area in the northwest, it is named clockwise as: Ward a, Ward b, Ward c, Ward d, Ward e, Ward f, Ward g and Ward h. Each ward area has different departments.

The inpatient department uses 8mx4m as a standard room, usually offering double and single rooms. Different Settings can meet the economic needs of different patients.

The inpatient department is a square module unit, with wards arranged at both ends, medical care functions arranged in the middle and two connecting corridors in the middle. Each ward is equipped with a toilet. The ward accommodates the space needed for rest, bath, toilet, sleep and other activities to be performed in the ward.

The distribution of ward types and number of beds are:

WARD	FLOOR	WARD TYPR	NUMBER OF BED
ward a. 52beds	1F	General Hospitalization	12double+2single
	2F	General Hospitalization	12double+2single
ward b. 44beds	1F	Newborn hospitalization Neonatal Intensive Treatment	7double 4
	2F	General Hospitalization	12double+2single
ward c. 50beds	1F	Orthopaedics and Traumatology General Hospitalization	12double+2single
	2F	General Medicine	10double+4single
ward d. 50beds	1F	General Medicine	10double+4single
	2F	General Medicine	12double+2single
ward e. 42beds	0F	Psychiatry	5double+6single
	1F	General Medicine	12double+2single
ward f. 52beds	0F	Emergency Medicine Cardiology	6doulbe+2single 6double
	1F	Day Hospital-Day Service Day surgery (4 ENT + 4 orthopedics and traumatology)	7double 4double
	2F	Rehabilitation and long-term care General Medicine	6double+2single 4single
ward g. 53beds	0F	Pediatric hospitalization General hospitalization	7double+3single 2double
	1F	Day surgery (18 general surgery + 2 urology)	7double+6single
	2F	Rehabilitation and long-term care	6double+2single
ward h. 54beds	0F	Delivery block (4 delivery rooms)	
	1F	Obstetric Hospitalization	12double+2single
	2F	General Medicine Orthopaedics and Traumatology General Hospitalization	7double 7double
C. 6beds	2F	CCU(Coronary artery)	6single
D. 9beds	2F	ICU(Intensive Care Unit)	9single

At the ground floor, ward a belong to orthopaedics and traumatology general hospitalization, ward b is pediatric hospitaliztion (with 2 beds for general hospitalization), ward c is obstetric hospitalization, ward d is rehabilitation and long-term care, ward e is psychiatry, ward f and ward g are general medicine, and ward h is emergency medicine and cardiology.

At the first floor, ward a belong to general hospitalization, ward b are newborn hospitalization and neonatal intensive treatment (with 1 bed for obstetric hospitalization), ward c is delivery block, ward d is rehabilitation and long-term care, ward e and f are general medicine, ward g is day surgery (with 18 general surgery and 2 urology) , and ward h are hospital-day service and day surgery (with 4 ENT and 4 orthopedics and traumatolgy).

The obstetric care unit consists of two parts: the childbirth area and the obstetric care unit, in which the childbirth area is on the first and second floor, and the wards are on the ground floor. Pregnant women giving birth are equivalent to minor surgery. Some pregnant women with broken or obstructed labor can give birth in the operating room of the second floor. The delivery area, the obstetric operating room, the obstetric care unit and the baby room are all located in ward c, with convenient vertical access. The delivery area and nursing unit are not on the same floor, and the delivery area has strict hygiene requirements, pollution cleaning and indoor cleaning requirements of the delivery room are the same as the sterile operating room. The childbirth area is equipped with predelivery room, delivery room, consulting room, baby room, family waiting room, and nurse office, warehouse and locker room for medical staff.In the module of obstetrics, there is no staff working area in the middle, so there is only a large corridor to facilitate the movement of hospital beds.

And at the second floor, ward a and b belongs to general hospitalization, ward c is delivery block, ward g is general medicine, and ward h are general medicine, orthopaedics and traumatology and general hospitalization.

According to the investigation of the main leisure ways of inpatients during their stay in hospital, resting or sleeping on the bed is the most important leisure way of the patients. During the pandemic covid-19 in Europe some experts underlined the importance uses double beds rooms as single to control infection

According to the survey results of inpatients' demand for the inpatient environment, it can be seen that the double room is the most popular type of ward, and the single room has a certain contradiction in terms of use demand and price expectation. Patients tend to have balconies, French Windows, warm color wards; Most patients have the need to understand the disease, the choice of activity space and entertainment is different, and outdoor activity space and watching TV are the main.

A survey of the daily working hours of nursing staff shows that most of their time is mainly spent in nursing, treating patients, and walking and visiting nursing units. When asked what was the most tiring thing at work, many respondents said it was constantly walking, followed by constant nursing work.It can be seen that moving back and forth in the nursing unit not only occupies a considerable part of the nursing staff's time, but also makes them feel physically and mentally tired. The survey results showed that the nursing staff mainly observed patients through the observation window on the door of the ward or through entering the ward. No one chose to observe patients in the nurse station or by other means. Entering the ward for observation was the main way of observation for most interviewees.When asked how they knew patients needed help, most interviewees did so through the call system, while others were found during inspections or informed by others. The help of others is especially important for patients who are more serious and less than conscious.[35]

In China, the layout of most wards is based on the regular column network of the inpatient building to separate each room. The separation method is to divide two wards on average between each cross column network, so the wards in the same hospital building are the same width, and the direction of depth may sometimes change. Due to the regular column network, the ward plane is also dominated by regular quadrilateral. At the same time, in order to combine the layout of the toilet in adjacent wards better, most wards adopt the mirror image and repeat, while a few wards repeat the layout in accordance with the same plane form. It can be seen that the plane form of the current wards is mainly simple and neat. Our wards are laid out in a mirrored and repeated way, which can better adapt to the regular column network of the building.

Ward layout: As for the layout of the wards, we adopted the re-corridor-style layout, which has the advantage of simple and neat structure. However, when the number of wards is too large, the corridor will be too long, which is not conducive to nursing. Therefore, we changed the original scheme design from 6 long wards to 8 short wards now.

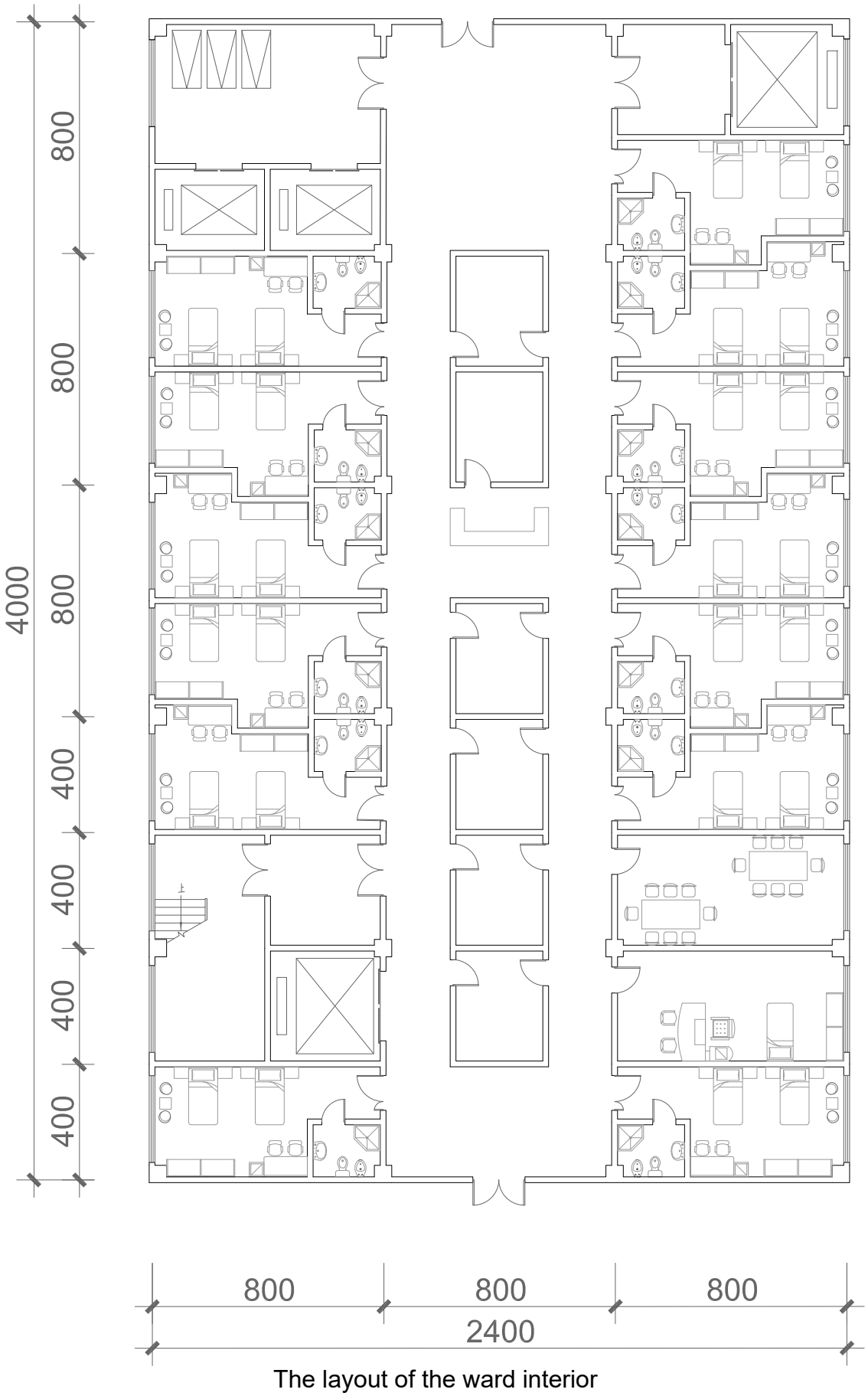
The bed placed and its mirror way: According to the position of the bed in the ward studied before, the bed should be placed on the left side after entering the door because it is more convenient for medical staff to use the right hand for nursing.However, in our scheme, the wards are formed in pairs, and the middle wall is not straight. The two wards are mirrored, so the beds cannot be uniformly placed on the left side of the door.

The layout of the ward interior: The door of ward is double asymmetrial door, wide 1.2 meters, can open a door to pass in and out only at ordinary times already, also can open the door completely, let sickbed pass smoothly. The door of toilet is 0.8 meters wide, open outward, can increase the space inside toilet so. After entering the ward, you can reach the first bed through the corridor with the toilet next to it. The two beds are 1.3 meters apart, with a bedside table and an instrument respectively. There is also a table, two chairs, a trash can, two cupboards, two small sofas and a small table in the ward. Considering that patients can see the scenery out of the window, especially for some patients who are more serious and can only rest in bed for a long time, it is appropriate to reduce the height of the windowsill so that these patients can see the scenery out of the window. The window is casement window, and the window design of the ward is more conducive to access to natural light. As the width required by the cabinet is narrower than that used by the table and chair, push the wall where the cabinet is located to the inside of the ward, and the table and chair space in the opposite room will be enlarged, as well as that in this room, so as to increase the space utilization. The size of the toilet is 2.5mx2m, which is large enough to hold the required sanitary ware.

Medical staff space in the middle of the ward unit: In the center of the ward unit is the working space for the medical staff, from one end close to the hospital to the other end of the function in turn is: locker room - nurse office - nurse desk - drug area - clean room - dirty room. When the medical staff come from hospital, they change their clothes, nurse desk is set at the center because this is the fastest location to get to any of the wards. Once a patient in any of the wards has a special situation to call for help, the medical staff can arrive at the scene at the fastest speed for treatment.

Ward unit traffic:
Horizontal traffic: Each ward unit has two corridors, separated by a middle staff room, with wards at both ends.Each corridor is 2.2 meters wide, enough for two beds to walk side by

side, and each corridor serves a ward on one side, which is more efficient than just one corridor, with no mixed person.

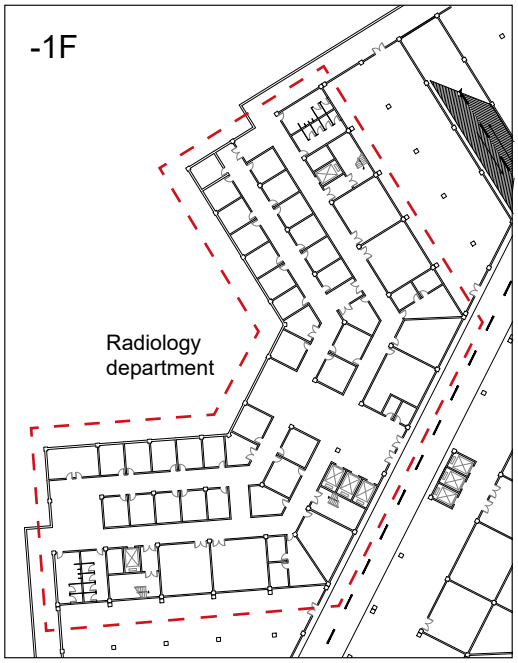


The layout of the ward interior

Vertical traffic: Ward at both ends of the unit has the elevator, away from the hospital center is at the end of the stairs, the stairs before a fire zone, close to the hospital for a period of the elevator also has the fire zone, but two in the front of the elevator is also a robot remains, the two together the elevator is set up for robot, they are responsible for transporting goods, the other two at the ends of the elevator open to all, connected to the lower level of the ward. Wards on the ground floor can be accessed either from the CD area or from outside the hospital, while wards above the ground floor can only be accessed by lift or by climbing the stairs. Fire control terrace are provided on every ward unit except the ground floor.

Other auxiliary rooms: In each ward unit, there is a dining room where patients and their families can easily eat; A consulting room is set up where patients can be treated. Morever two rooms are auailablefor clean and dirty, two toliets for the medical staff, one toilet for visitors, an infirmary and a small kitchen for the patients.

4.3.5 Other hospital department



- Radiology department

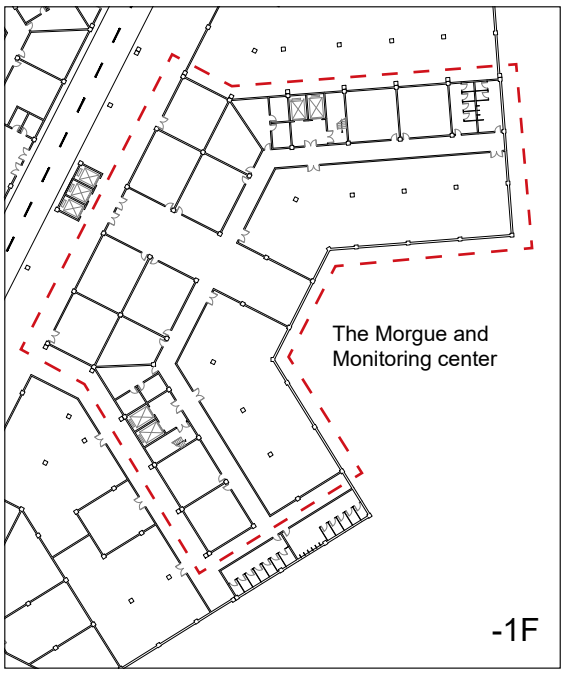
In the hospitals of many departments, radiology department is an important auxiliary examination department, radiology department of electromagnetic radiation produced by various types of equipment are extremely dangerous, as far as possible to avoid the hospital complex magnetic environment, the electromagnetic spectrum crowded, electromagnetic interference caused by various kinds of damage and interference, eventually to weaken or even eliminate the influence of electromagnetic radiation.It is not only necessary to do isolation work indoors, but also to set up obvious ionizing radiation warning signs outside the machine room. Moreover, doctors also need to wear corresponding radiation protective clothing to observe and operate in the control room during work.

About equipment in the radiology department:

1.CT machine is used to scan a certain part of the human body with X-ray beam according to the given thickness layer. When the X-ray arrives at the surface of the human body, part of it is absorbed by tissues, while the other part goes through the human body.As the thickness of each tissue of the human body is different, the intensity of the signal received by the detector is also different, and finally the detection image can be formed.

2. Digital gastrointestinal equipment is a medical radiological equipment, which is only used for gastrointestinal fluoroscopy and photography, such as chest photography, gastrointestinal examination, skull and whole-body bone photography, etc.

3.MRI device is to place human body in a special magnetic field and excite hydrogen nucleus in human body with radio frequency pulse, causing resonance of hydrogen nucleus and absorbing energy. After stopping the rf pulse, the hydrogen nuclei emit radio signals at a specific frequency and release the absorbed energy, which is captured by an external receiver and processed electronically to an image called an MRI.



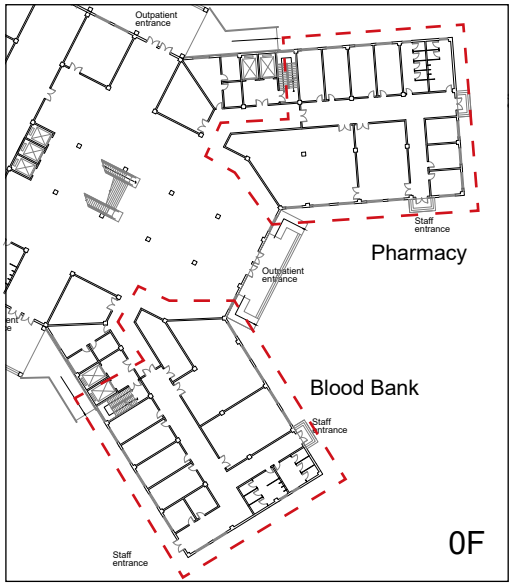
- the Morgue&Monitoring center

In large general hospitals, there are many patients with complex diseases and critical conditions, and a certain number of patients die. The hospital mortuary undertakes the service for such patients and their families. Mortuary work is to respect the dead and comfort the living.

The monitoring center should give full play to the real-time monitoring function of the security monitoring system, further strengthen the monitoring equipment and information security, maintain the overall safety of the public, clarify the monitoring personnel and responsibilities, standardize the security monitoring system of the administrative departments of the government, and improve the safety management ability of the hospital.

- Underground logistics

The underground floor is the unloading area for the whole hospital. There are large warehouses, which is also the place for large water and electricity equipment. There are also kitchens, freezers and cleaning rooms. These are only open to hospital staff.

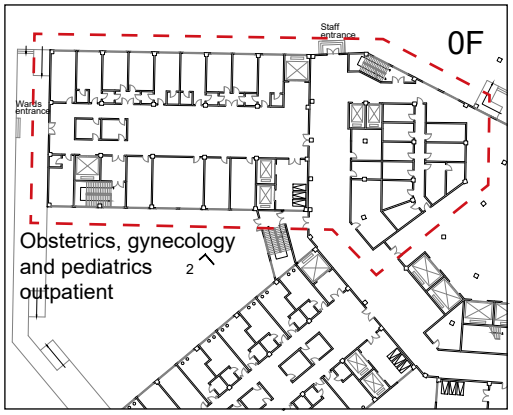


- Outpatient hall, specific outpatient and canteen

The outpatient hall are separated in two parts: pharmacy area and blood bank.

At the ground floor of CD area, there are 3 specific outpatient: pediatric outpatient, enteric outpatient and hepatitis outpatient. Each outpatient area has consulting room, registration, assay and pharmacy, also rooms that require special functions for special outpatient services.

Once inside the hospital main gate, it arrived at procedural hall, facing registration and toll, and then an escalator to the first floor. The whole hall was very large and spacious.



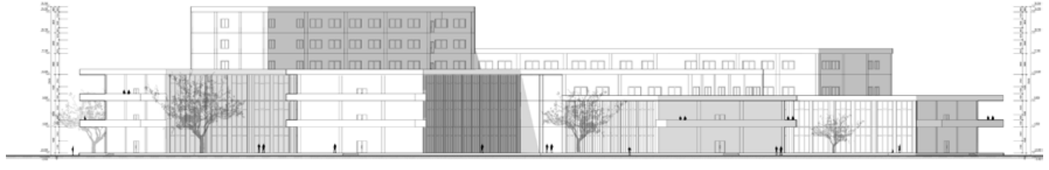
There are two canteens located at hospital. The one is at ground floor which served for all patients and their family mebers, also if medical staff want to go there to eat. The dining room is directly above the kitchen; The other one are setting on the fourth floor, kitchen is also at here. This canteen just served for medical staff.

There are also dining areas in each ward module.

4.4 Trofarello hospital elevation

FRONT ELEVATION

0 5 10 15 20 25M



LEFT ELEVATION

0 5 10 15 20 25M

Our site is located between the Trofarello residential area and a factory site. The residential area is mainly red tile roof, while the factories are mainly white blocks, so the facade color of the hospital is a combination of red and white: the hospital center, AB space are red, because they include emergency department, red is bright-colored and easily be seen.

The total hospital building area is 93881.23 m^2, that has one underground level and five floors above the ground. Each floor area square meter is:

Underground floor: 23967.56 m^2
Ground floor: 18707.94 m^2
First floor: 20299.61 m^2
Second floor: 19776.64 m^2
Third floor: 6112.56 m^2
Fourth floor: 2508.46 m^2
Fifth floor: 2508.46 m^2

The selection and modeling of architectural components, materials and colors pursue simplicity, and the use of simple design elements reflects practical and generous principles.

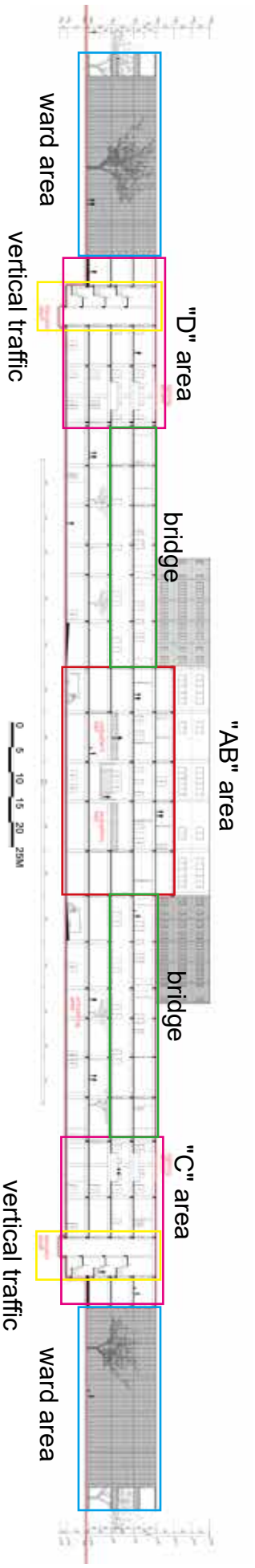
Large windows in the ward area provide sufficient light and ventilation, extending from the ward area to the center of the building and reaching the brightly colord emergency area and medical technology area.

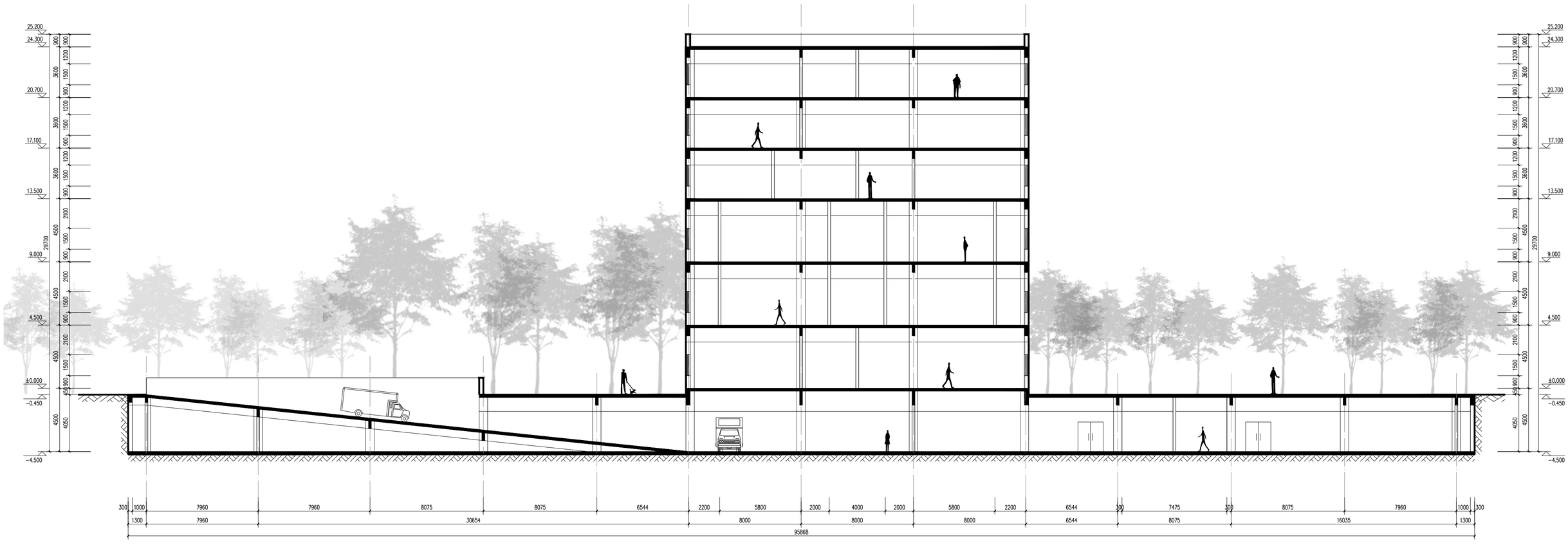
4.5 Trofarello hospital section scheme

Long section can intuitively see the interconnection of each functional block, the interlocking of external and internal space, and the vertical traffic organization.

As can be seen from the figure, there is space AB in the middle of the hospital, which is the location of the most important emergency department and operating room of the hospital. Many critically ill patients will be sent to the center of the hospital for emergency treatment. From the center of the hospital, the CD space is connected by a north-south bridge, and closely connected to the CD space are the wards of various departments. Compared with AB space, CD and ward area are the places where patients and their families stay for the longest time and where personnel flow is the most intensive. Therefore, attention should be paid to the psychological status of patients and their families, as well as the distinction of space and streamline between patients, their families and medical personnel. The ward is the daily residence of inpatients, and our design should take into account the physical and psychological needs of living here, so that patients can live as comfortable as home, which can also speed up the improvement of their condition.

From the section, you can see the role of vertical transportation organization in the various departments of the hospital. This section mainly cuts into three vertical traffic structures: two in C/D space and one in B space. These three are the most important and largest vertical traffic organizations in the hospital, located in the outpatient department and the hospital lobby on each side. Since the outpatient department is the most densely populated area, four lifts and a staircase are necessary; In addition, four elevators and two staircases are located at both ends of the CD space, which are connected to the underground level and serve as an escape function. The vertical traffic in the middle hospital hall is the escalator and the staircase, the staircase is located in the middle, each side is the escalator up and down.The hospital hall is also one of the places with dense personnel, and it is also the place with the largest and most imposing space inside the hospital. Therefore, it is necessary to choose escalators and stairs with long steps.

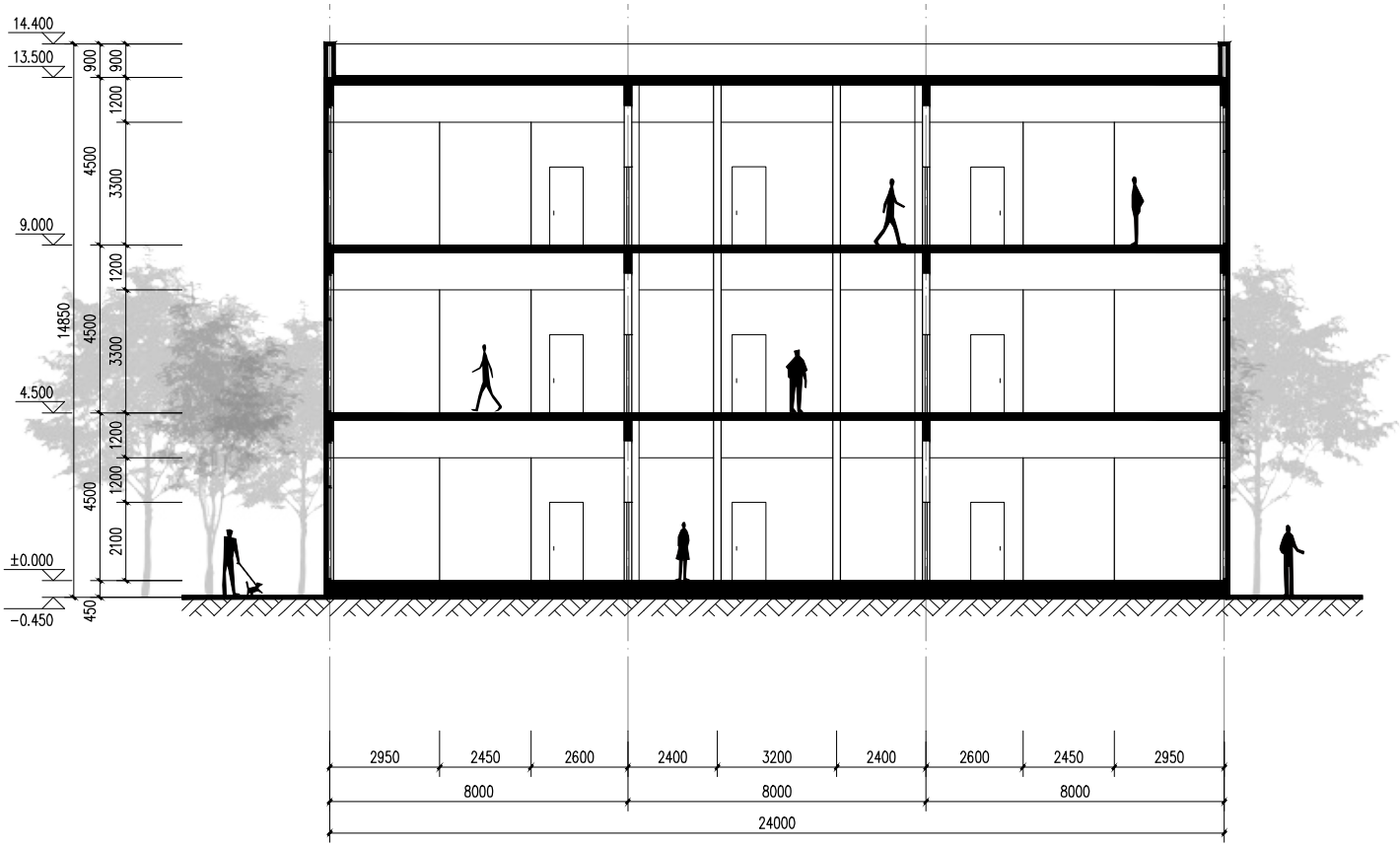




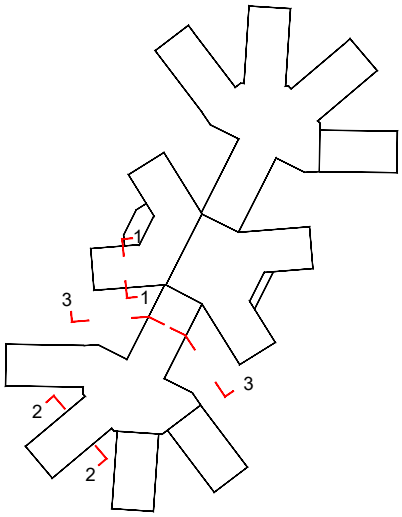
section 1-1 operating room 1:200

Section 1-1 is space A, with A total of 7 layers, including one underground layer and six above ground layer. It is the highest part of the whole hospital, with a total of 25.2m.From the basement floor to the fifth floor, the functions of each floor from the bottom to the top are: Radiology Department, Emergency Department, Day Surgery Operating Room, Surgery Operating Room, Clinical Lab, Staff Canteen and Administration Area. Space A covers the radiology department, emergency department and operating rooms, the most important parts in the hospital, which is located in the center of the hospital.

It can be seen from the section that dirty corridor and clean corridor are arranged on the left and right side of the operating room in the first floor and second floor respectively to separate dirt and clean goods.



section 2-2 wards 1:200

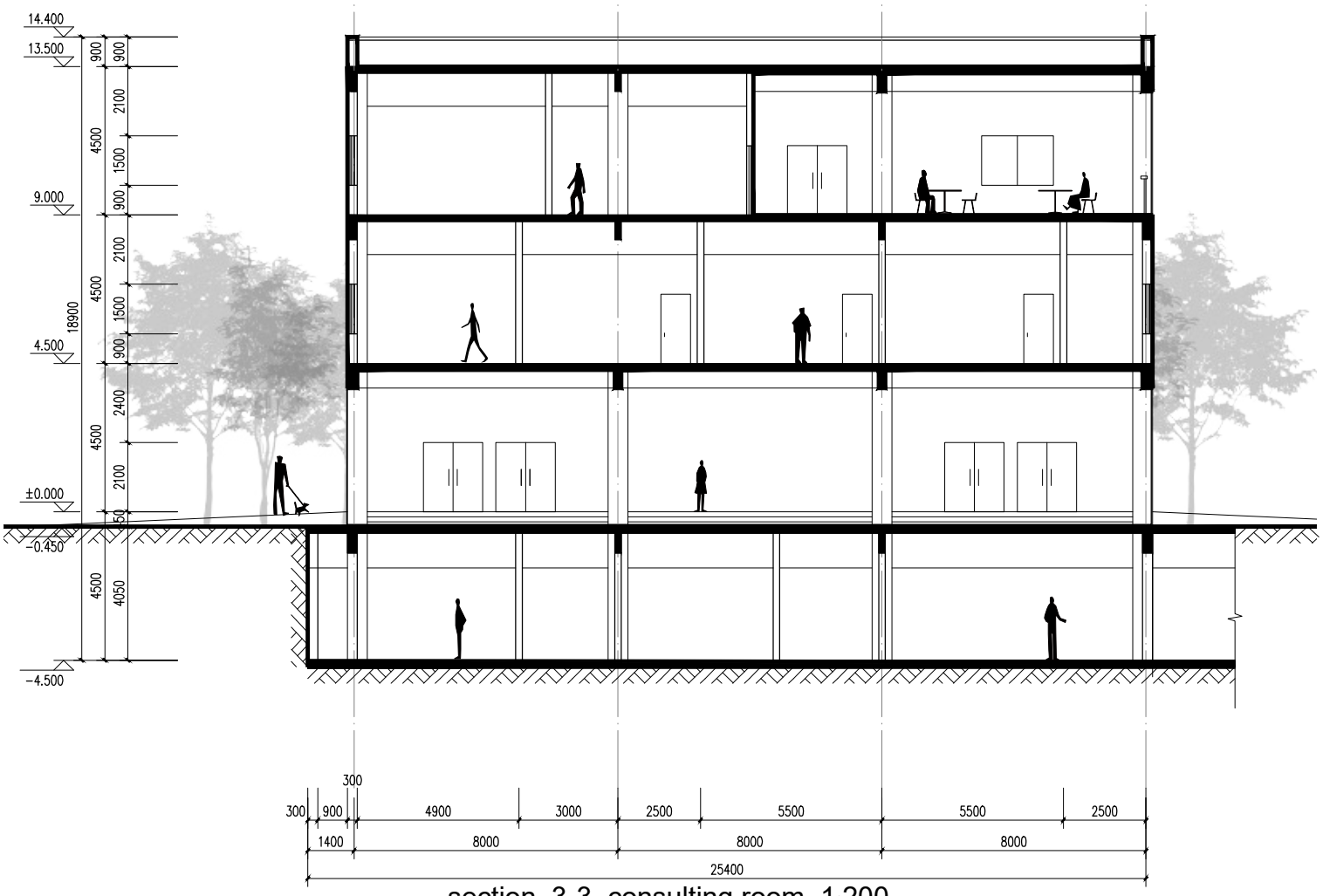


Section 2-2 is a section of the ward. We can intuitively see the height of the ward, the number of floors, the combined use of architectural space, the structural relationship in the building section, and the spatial composition within the ward unit.

From the previous description, our ward unit is a rectangular shape in the form of two corridors, each of which is near the external side of the ward and the elevator staircase, and the other side, in the middle of the ward unit, is the shared room for medical staff.

Section 3-3 is the consulting room and resta area on the bridge.

The ground floor is the external space with a gate to the CD space. On the first floor is a consulting room, one is a patient corridor, the other is a medical worker corridor, and the middle is a consulting room. On the secondfloor is a terrace, an operating patient corridor, and a passage&bar. The terrace allows a distant view of the scenery near the hospital. Operating patient corridor is a special corridor to transport patients for surgery back and forth between the ward and the operating room. The passage in the middle connects AB space and CD space, with bar and some tables and chairs for people to have a rest and chat.

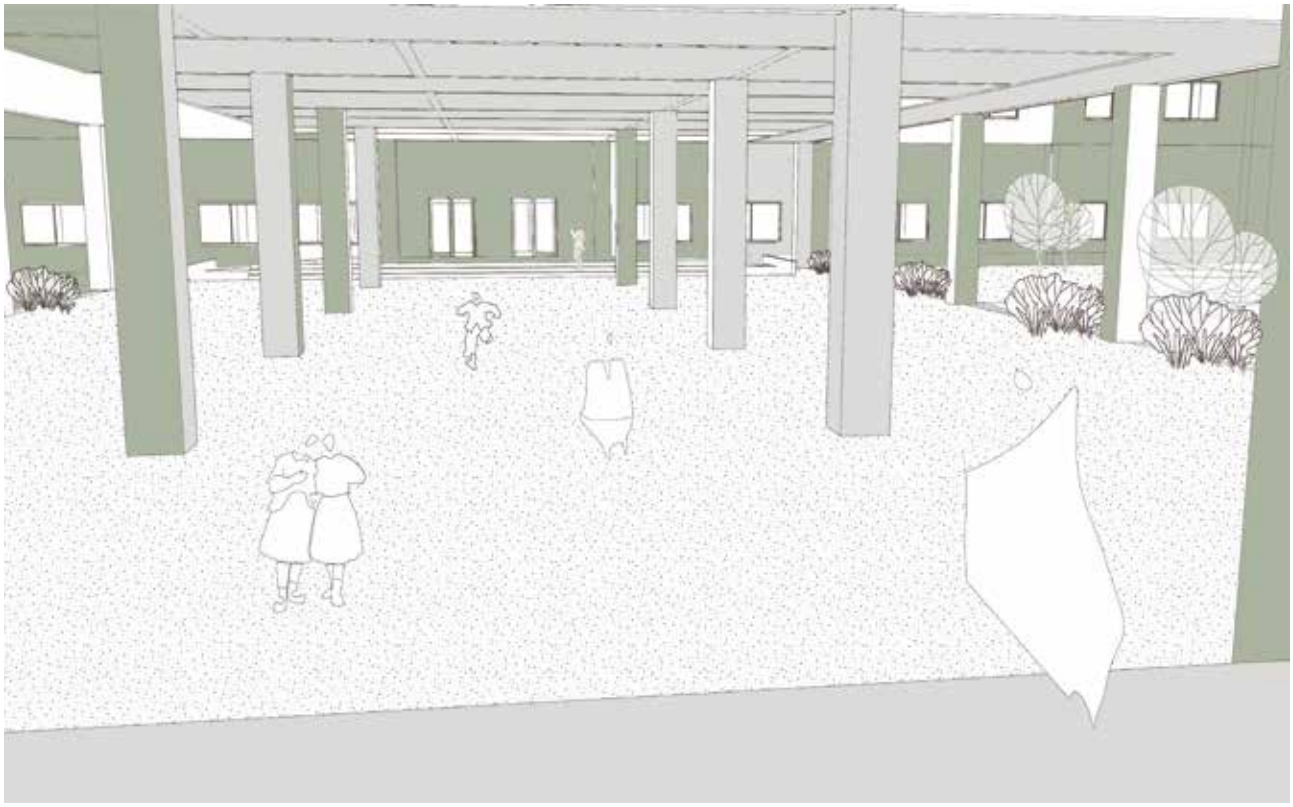


section 3-3 consulting room 1:200

4.6 Trofarello hospital perspective view

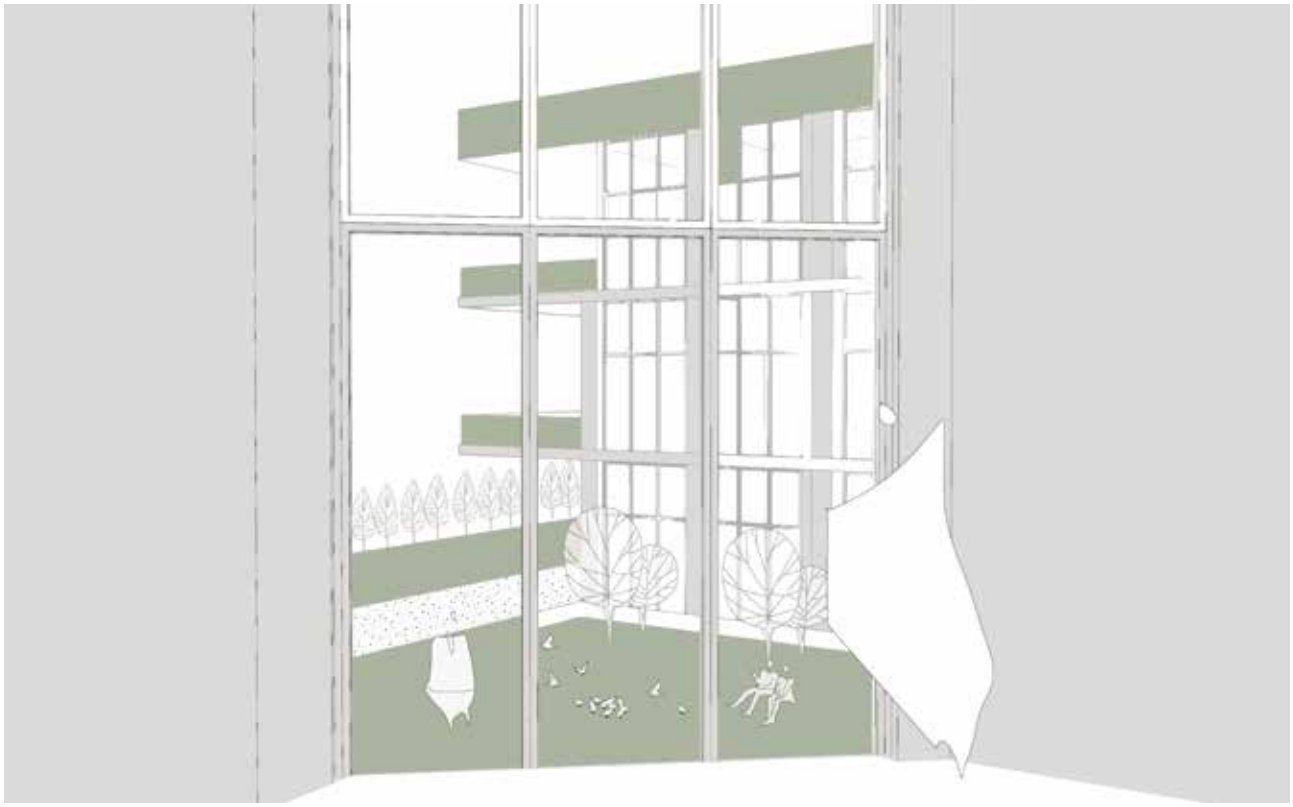
aerial view of yard

side entrance of outpatient hall



main entrance of the inpatient building

outdoor cafe area on the second floor



look out of the wards

4.7 Trofarello hospital structral design

The total construction area of the proposed TROFARELLO hospital is 68915.23 square meters, the main building is X-shaped, and the north and south auxiliary buildings are palm-shaped, each with 4 inpatient buildings. The north-south length is 307.5 meters, the east-west direction is 159.2 meters, and the main structural span is 8 meters.

The hospital as a whole consists of a 7-story outpatient and emergency building and a 3-story inpatient building. Due to the large difference in the number of floors and the load between the outpatient and emergency building and the inpatient building, a settlement joint (also seismic joint) is set between the outpatient and emergency building medical technology building and the inpatient building to make it two independent structural units to facilitate Settlement and earthquake resistance.

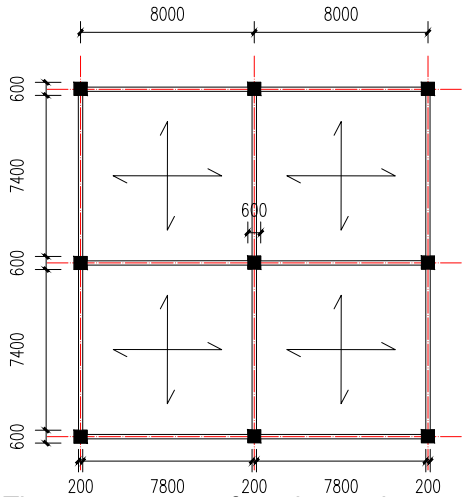
In the structural design of the hospital, considering the large volume of the overall building and the scattered functions, we used two structural systems, one is a reinforced concrete structure, which is mainly used for the main structure of the hospital, including outpatient, emergency, and operating rooms. , Inspection area, office and auxiliary facilities, etc. The other is a prefabricated reinforced concrete structure, which is only used for ward areas where the scheme is unified.

Child name	Number of underground floors	Number of floors above ground	Concrete structure length×width×height (m)	Structural system	Slab beam structure	Basic form
Outpatient, Emergency and Medical Technology Building	1	6	144.2×120.7×29.7	Frame structure	Cast-in-place slab	Pile foundation under column cap
Inpatient building	1	3	45.2×24.2×14.4	Prefabricated concrete structure	Prefabricated slabs and beams	

Overview of each structural subitem of the project

4.7.1 Reinforced concrete frame structure for the main building

4.7.1.1 The plan structure design of the main building

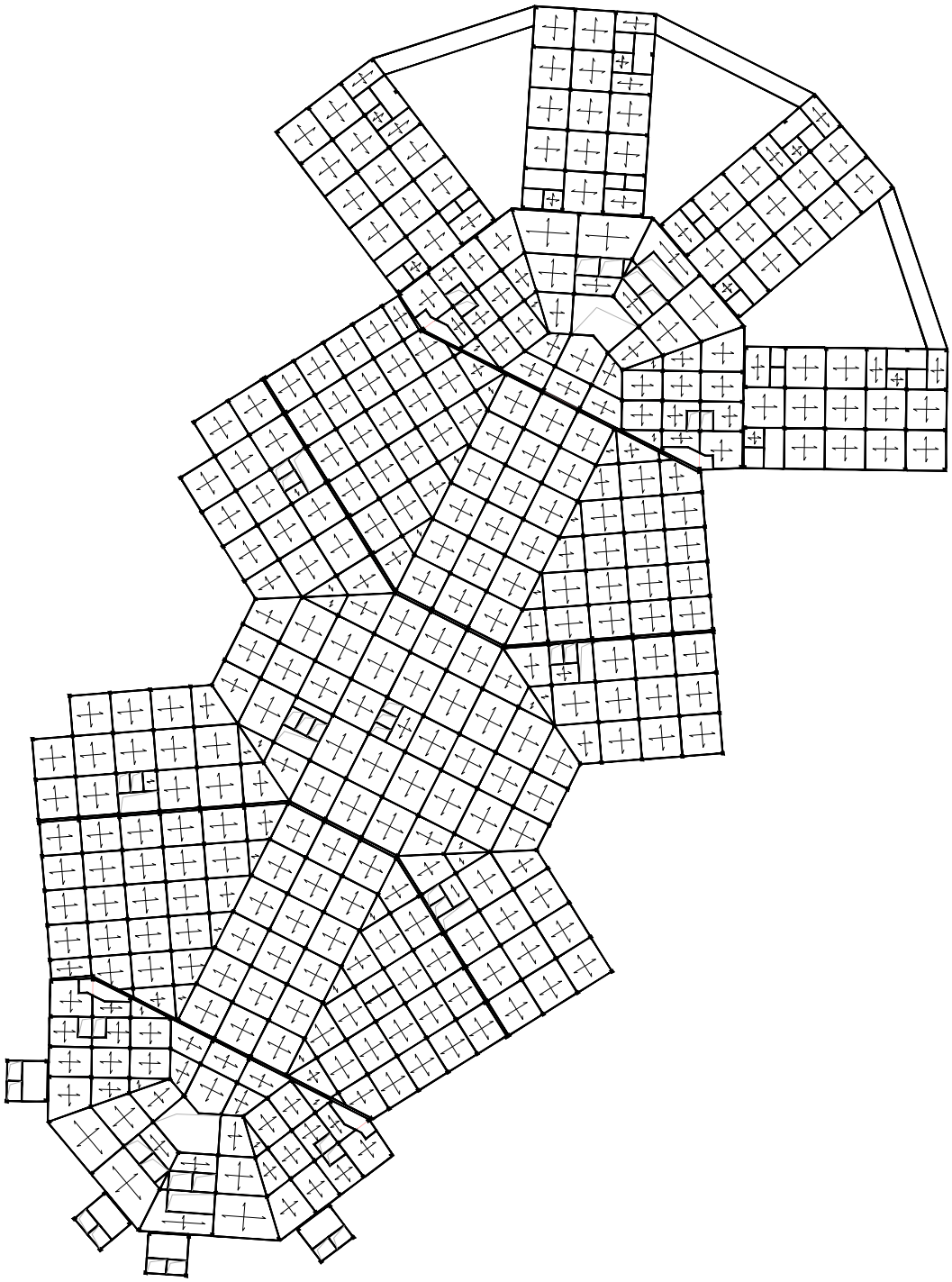


The arrangement of continuous beams, columns and floors[40]

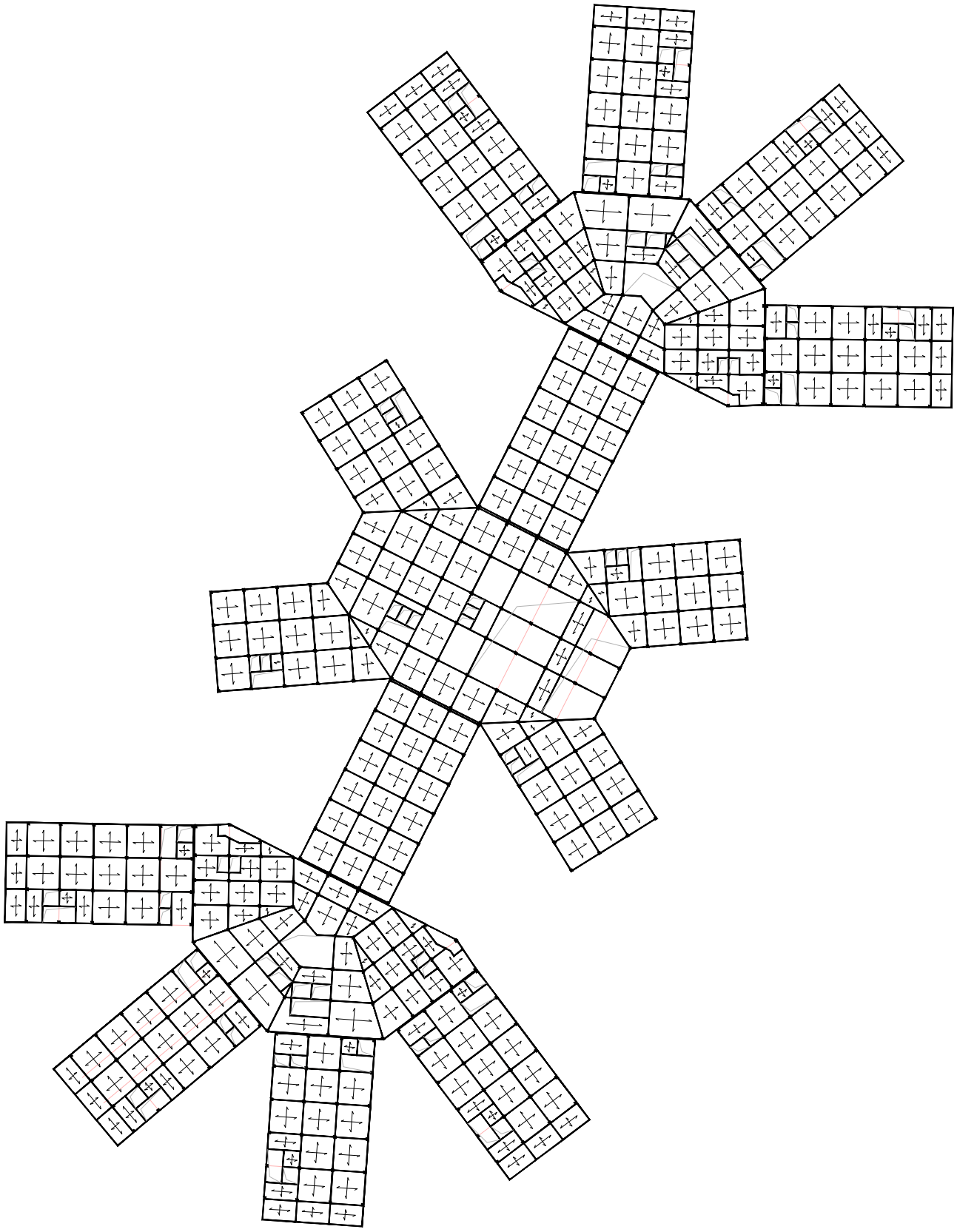
In the frame system, the layout of the floor joists determines the layout of the floor.In this case, we designed a main girder system and a secondary girder system.The floor slab will have a continuous structure similar to a plurality of supporting beams.

The layout of tiled columns should take into account the relationship between the inertia distribution and the axis of gravity to prevent the horizontal action of seismic acceleration from causing violent rotation of the scaffold.

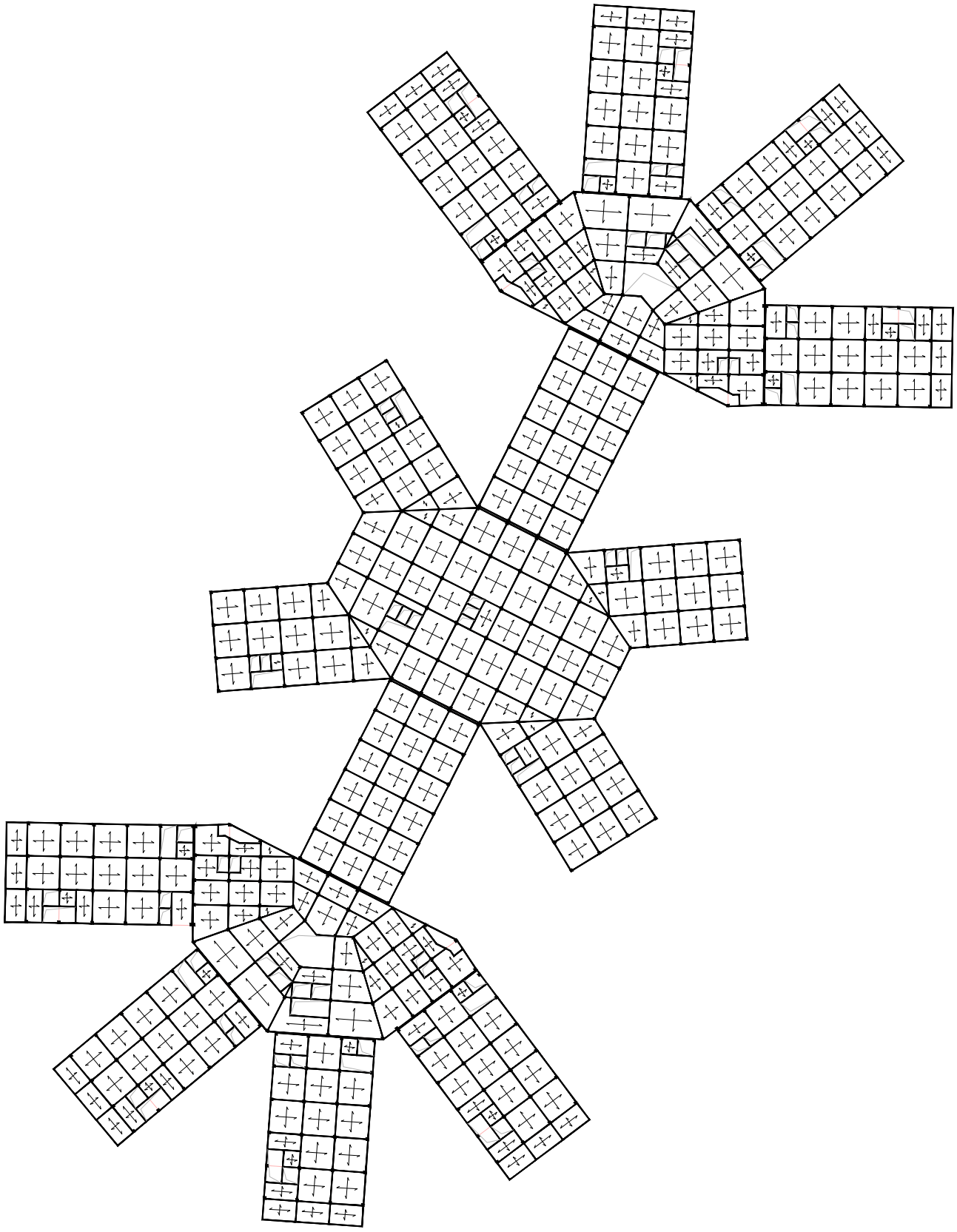
The direction of the main building floor is divided into five parts according to the structure. The structure of the inpatient building is scattered, but the form is the same. Below is a schematic diagram of the structure of each floor.Taking into account the distance between pillars a reinforced concrete cross beam ceiling can be adopted.



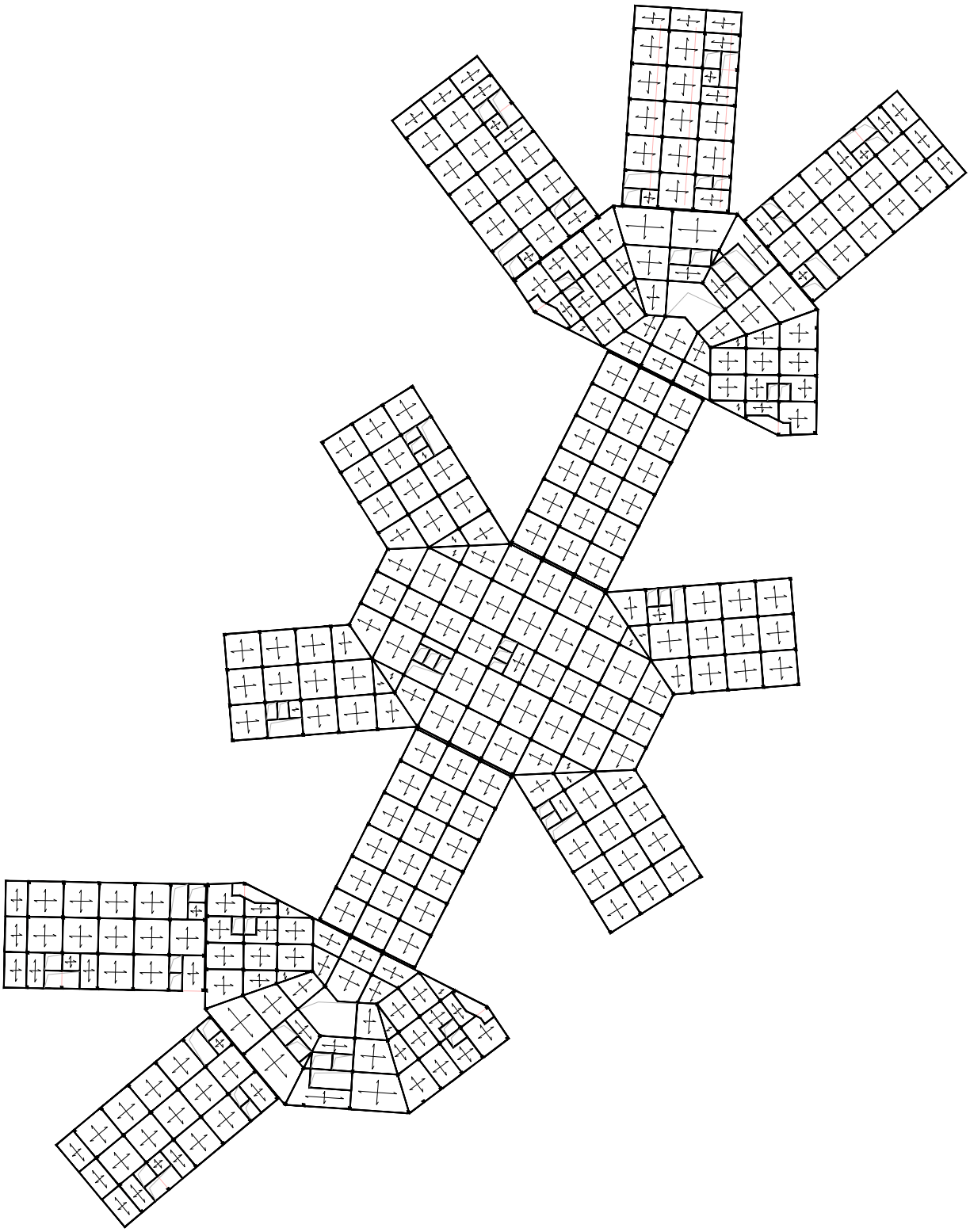
-1F plan structure



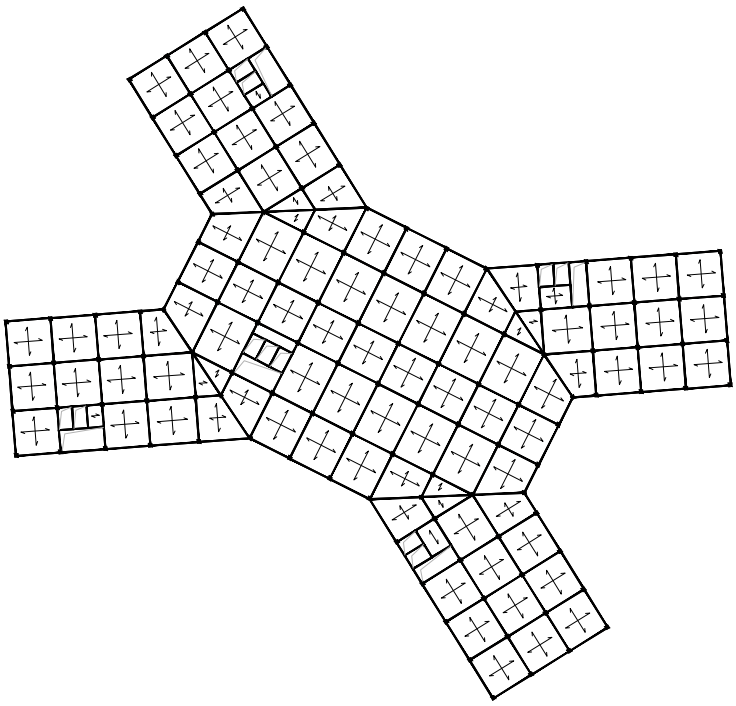
0F plan structure



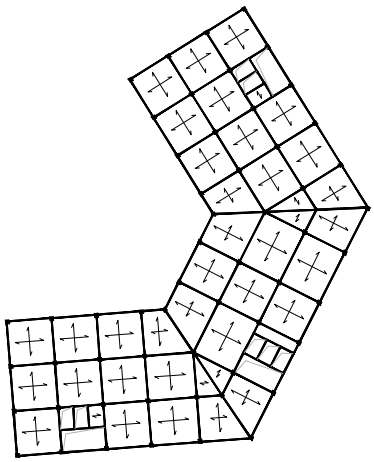
1F plan structure



2F plan structure

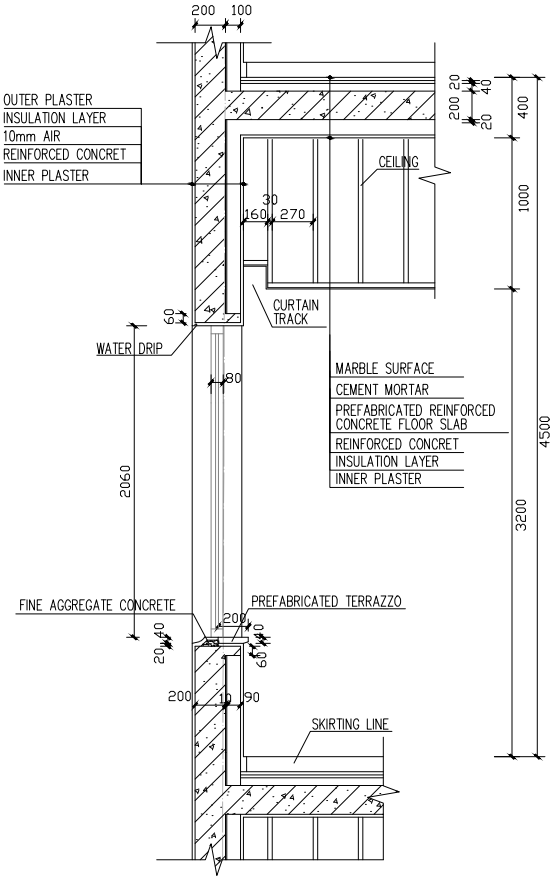


3F plan structure

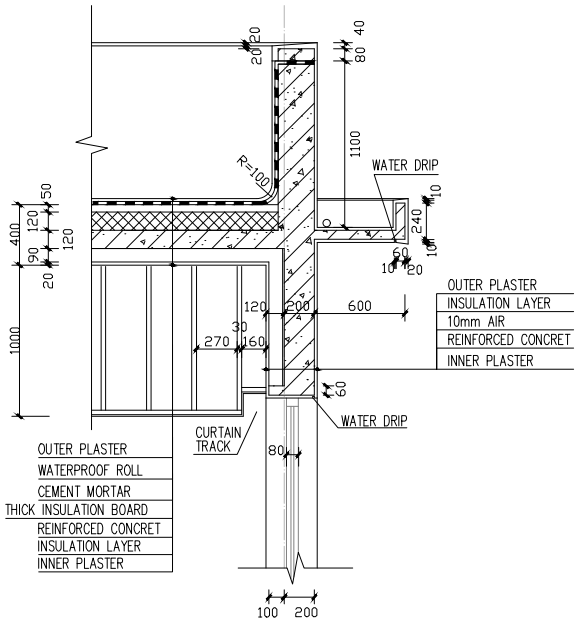


4/5F plan structure

4.7.1.2 Detail of external wall in the structure of main building



hospital main structure
exterior wall details 1:50

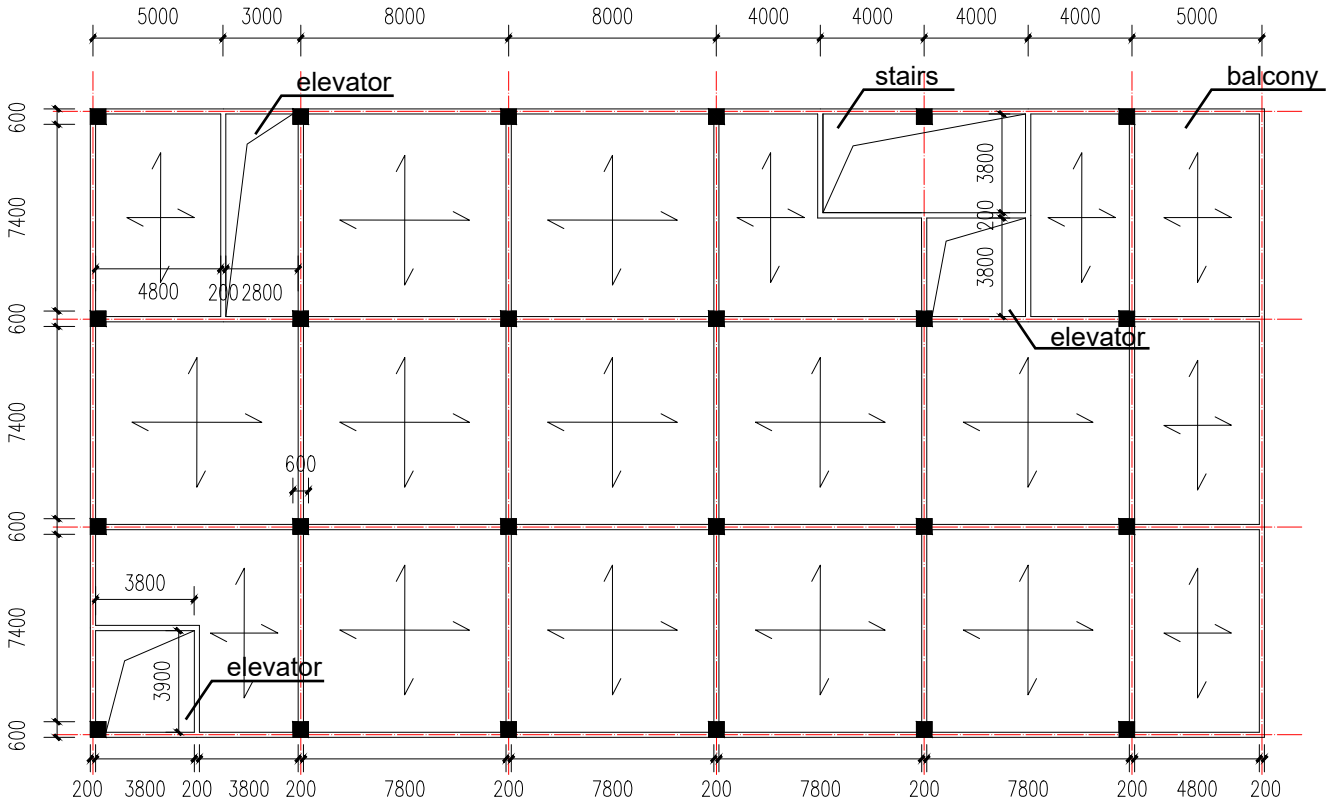


hospital main structure
roof parapet details 1:50

4.7.2 Prefabricated reinforced concrete structure for the wards

4.7.2.1 The plan structure design of the wards

The picture below is the structural design of the beams, columns and floor of the hospital building, including the separated staircase and elevator, and the cantilevered balcony design.



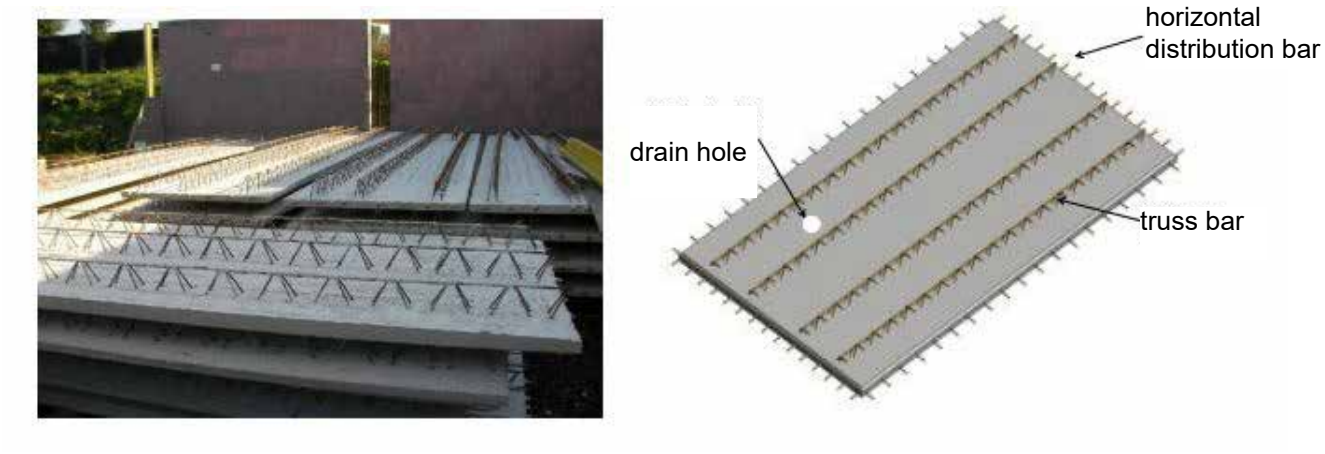
The wards arrangement of continuous beams, columns and floors

4.7.2.2 Main types of precast concrete components

At present, precast concrete components can be divided into horizontal components and vertical components according to the structural form. The horizontal components include prefabricated laminated panels, prefabricated air conditioning panels, prefabricated balcony panels, prefabricated stair panels, prefabricated beams, etc.; vertical components include prefabricated staircase partition walls Boards, prefabricated interior wall panels, prefabricated exterior wall panels (prefabricated external wall bay windows), prefabricated parapets, prefabricated PCF panels, prefabricated columns, etc.

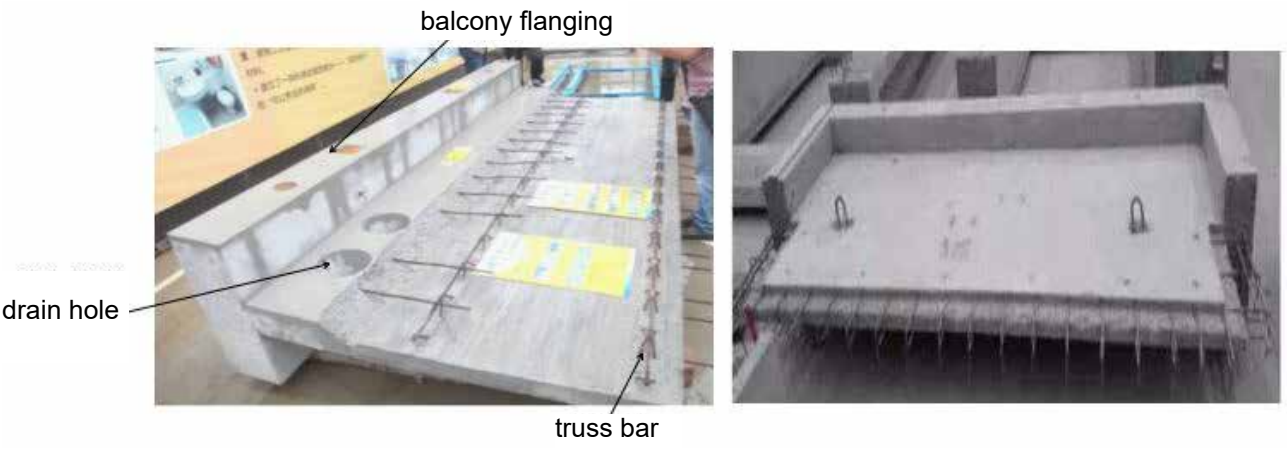
Prefabricated components can be divided into primary pouring concrete components and secondary pouring concrete components according to the number of concrete pouring during molding. Among them, primary pouring concrete components include prefabricated laminated panels, prefabricated balcony panels, prefabricated air conditioning panels, prefabricated interior wall panels, and prefabricated stairs. , Prefabricated beams, prefabricated columns, etc.; secondary pouring forming concrete upper components include prefabricated external wall panels (integrated thermal insulation and decoration external wall panels), prefabricated parapets, and prefabricated PCF panels.

(1) Prefabricated laminated slab:In buildings, a combination of prefabricated and cast-in-place concrete floor structure. The prefabricated laminated floor (the thickness is generally 5~8cm) and the upper cast-in-place concrete layer (the thickness of 6-9cm) are combined into a whole and work together. The laminated board adopts the ring-shaped production line for one-step casting and molding, and the surface is mechanically roughened. Into the steam curing kiln for maintenance, circulating flow operation. One side of the template is fixed by bolts, and the other sides can be fixed by magnetic boxes. The ribs need to be coated with super retarder and rinsed with high pressure water after removing the mold to form a rough surface.[41]



prefabricated laminated slab[40]

(2) Prefabricated balcony panels: projecting the cantilevered components of the facade of the building.According to the form of components, it can be divided into laminated slab balconies, fully prefabricated slab balconies, fully prefabricated beam balconies, and according to the construction practices, it can be divided into closed balconies and open balconies.The prefabricated balcony slabs are effectively connected by the casting layer after being welded into the main structure by reserved embedment parts and anchoring steel bars.[41]



prefabricated balcony panels[41]

(3) Prefabricated stair board: The precast concrete members used in the stair are generally clear water members, which no longer carry out secondary decoration and replace the traditional cast-in-place stair structure. They are generally composed of ladder board, support section at both ends and rest platform section.Can divide by the form to run stair and scissor type to run stair singly commonly.Stair adopts vertical production, layered

material vibration, attached vibrator with vibrating rod.Industrial production is better than cast-in-place stair quality, high precision shape, clear edges and corners.[41]

prefabricated stair board[41]

(4) Prefabricated inner wall panels: in the assembly of integral buildings, the steel bars of the upper and lower prefabricated inner wall panels are also connected by sleeve grouting as the prefabricated components of load-bearing inner partition walls.

The horizontal steel bars between the inner wall panels are connected by integral joints. The circular production line is used for casting and forming. Magnetic base can be used for embedded installation, but displacement should be avoided during vibration.[41]

prefabricated inner wall panels[41]

prefabricated exterior wall panels[41]

(5) Prefabricated exterior wall panels (prefabricated exterior bay Windows) : It mainly refers to the load-bearing exterior wall panels in the assembly of integral building structure. The main reinforcement of upper and lower exterior wall panels is connected by grouting sleeve, and the integral joint type cast-in-place connection is used between adjacent prefabricated exterior wall panels. Prefabricated outer wall panels are divided into outer

leaf decorative layer, middle sandwich insulation layer and inner leaf bearing structure layer.There is also exterior siding with bay windows.

Prefabricated outer wall panels are produced by means of backbeating technology and fixed pedestal method. Concrete is poured in layers, steamed and raised by in-situ covering bitter cloth, and lifted and hoisted by plate turning machine.Among them, the precast concrete sandwich composite insulation wall board pouring the outer leaf wall first, laying the insulation board, and then pouring the inner leaf wall, the two layers of concrete wall board are connected through the insulation connector, sandwiched with lightweight and efficient insulation materials, with load-bearing, envelope, heat preservation, heat insulation, sound insulation, decoration and other functions.The inner layer of concrete is the structural layer, the outer layer is the decorative layer, which can be made into different styles according to different architectural styles, such as plain concrete, colored concrete, brick finishes, stone finishes, etc.[41]

prefabricated inner wall panels[41]

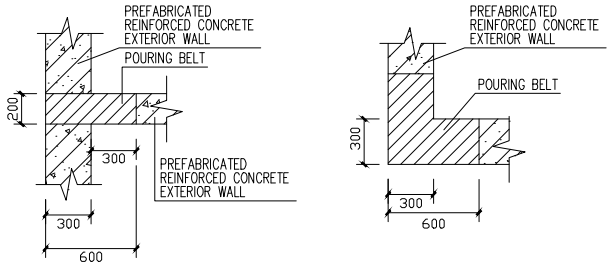
prefabricated exterior wall panels[41]

(6) Prefabricated beams: beam members are manufactured in factories and installed on site. Prefabricated beams are connected by secondary pouring through exposed steel bars and embedded parts.[41]

(7) Prefabricated column: the column members are manufactured in the factory and installed on site. The vertical steel bars of the upper and lower layers of the prefabricated column are connected through the grouting sleeve.[41]

4.7.2.3 Connection method between prefabrecated shear walls

The adjacent prefabrecated shear walls in the floors shall be connected by integral joints. Our design complies with the following provisions: when the joints are located in the constraint edge member area at the junction of the vertical and horizontal walls, the shadow area of the constraint edge member shall be fully post-cast concrete, and closed stirrups shall be set in the post-cast section;When the joint is located in the structural edge member area at the junction of vertical and horizontal walls, the structural edge members should all use post-cast concrete.When the post pouring section is set on only one wall, the length of the post pouring section should not be less than 300mm.



with wing wall corner wall

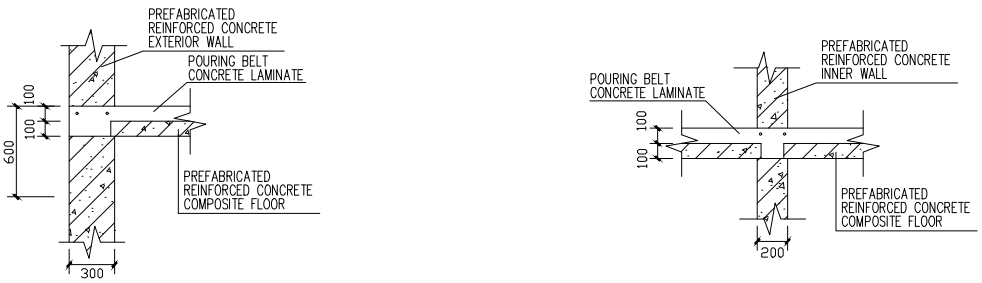
wards prefabricated structure
pouring belt wall connection plan 1:50

4.7.2.4 Connection method between prefabrecated shear wall and beam

Closed post-cast reinforced concrete ring beams shall be installed on the top of the precast shear walls of the roof and the floors that are closed into the facade. Our design complies with the following requirements: the width of the section of the ring beam shall not be less than the thickness of the shear wall, and the height of the section shall not be less than the thickness of the floor slab and the larger value of 250mm;Ring beams should be integrated with cast-in-place or superimposed buildings and roofs.

end of the node[42] intermediate node[42]

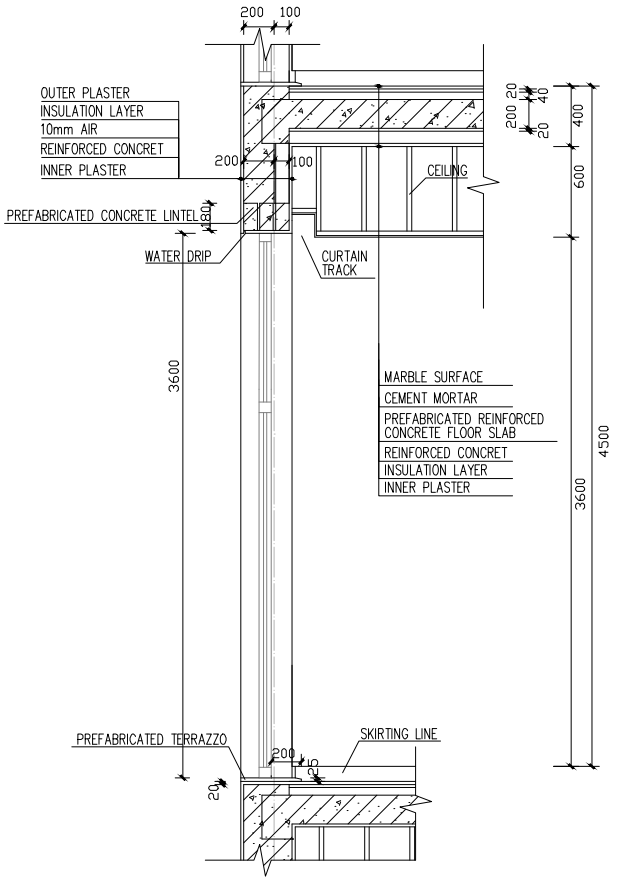
wards prefabricated structure section (pouring belt with beams) 1:50



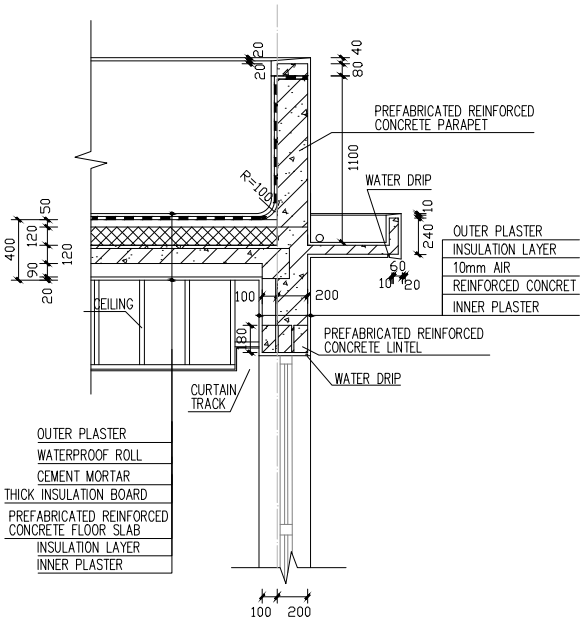
end of the node[42] intermediate node[42]

wards prefabricated structure section (pouring belt without beams) 1:50

4.7.2.5 Detail of external wall in the structure of ward building



wards prefabricated structure
exterior wall details 1:50



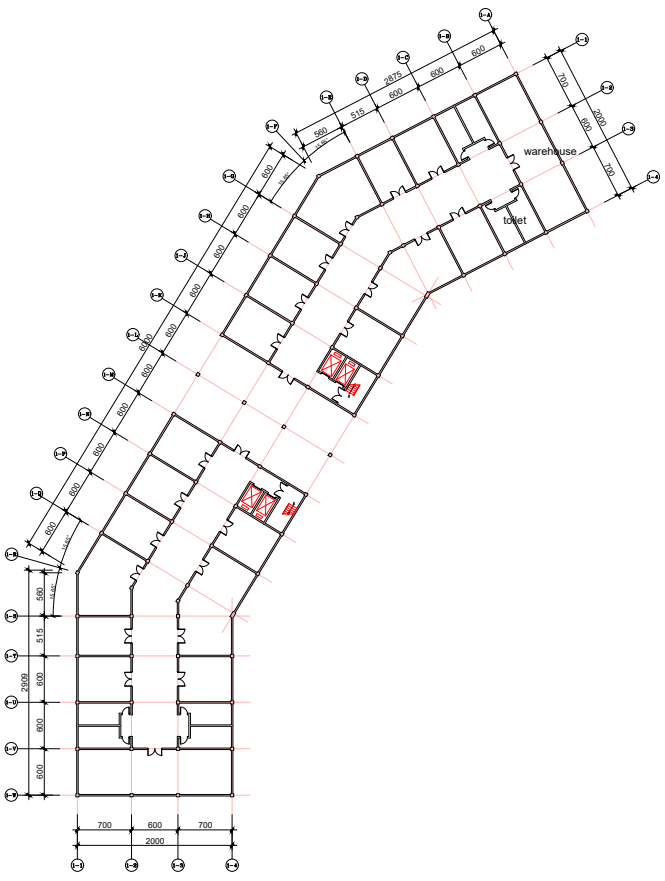
wards prefabricated structure
roof parapet details 1:50

Chapter 5
Other auxiliary areas on the hospital site

As mentioned above, the site is divided into three parts: the first part is the base of the hospital, the second part is the Parking Building and Hospice, and the third part is the commercial area.The second part and the third part complement each other with the hospital, providing convenience for people coming to the hospital and stimulating the development of the surrounding economy.Hospice provides the most comfortable room for hospice residents. Hospice has a pleasant environment that gives patients a pleasant mood and a pleasant view that helps them to reach their final days.Commercial area is divided into shopping malls and hotels, which have some places for hospital staff to rest. Other rooms are open to the public, both to visit relatives and friends of patients, and to rest for people working nearby.

5.1 Commercial area

5.1.1 Shopping mall



commercial 0F

-Basic dimensions and column grid arrangement

The shape of the mall module and the shape of the hospital complement and reflect each other. The basic column network of the shopping mall have two systems, the middle is 6mx6m, the two sides are 6mx7m. The north and south end is the unloading area and warehouse of the shopping mall, and the middle area is the commercial room. The size of one room is 6mX7m, which is the same as the cylinder network. Each floor is equipped with four toilets and four elevators, two for commercial elevators, two for freight elevators, one for catering and one for retail products.

-The basic characteristics of shopping mall

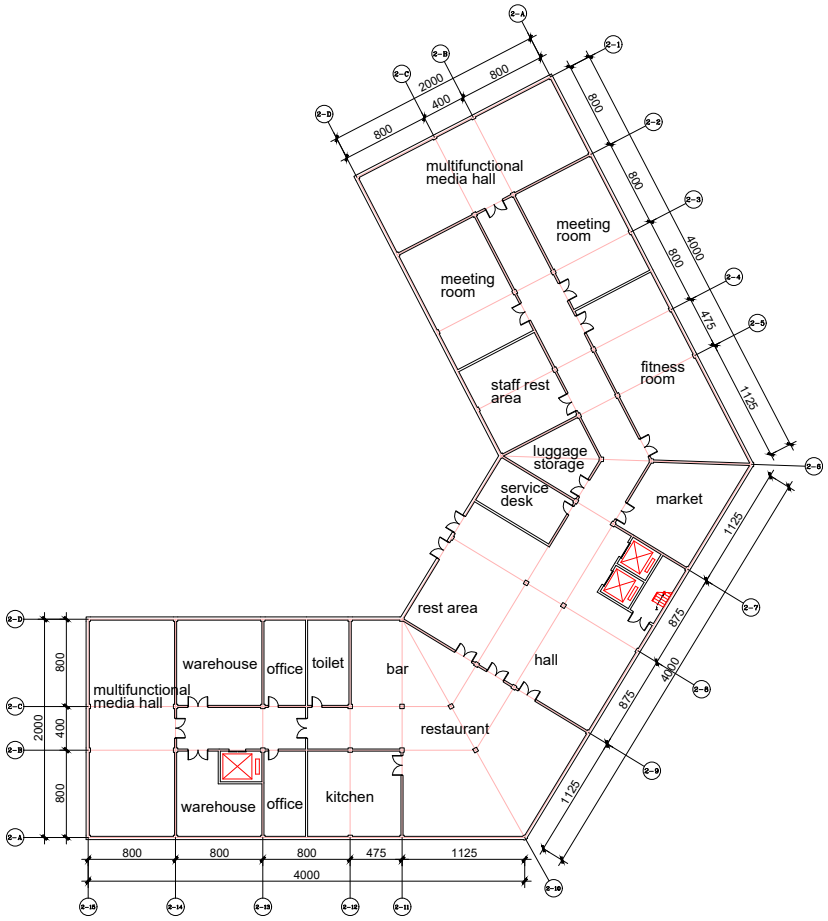
The center of the first floor of the mall is empty, connecting the road to the hotel from the parking building.

In addition to the parking building on the west side of the shopping mall, there is also a row of parking spaces along the street. People who go to the shopping mall and hotel can choose here to park nearby. The mall is mainly a retail store and a restaurant, providing convenience to the people who come to the hospital and the surrounding neighborhoods and factories.

5.1.2 Hotel

-Basic dimensions and column grid arrangement

The shape of the mall module and the shape of the shopping mall complement and reflect each other. he basic column network of the hotel have two systems, the middle is 8mx4m, the two sides are 8mx8m. The depth of the rooms on both sides is consistent with the column grid. Set functional areas on the ground floor, including multifunctional media hall, meeting room, restaurant, kitchen, bar, market, office, warehouse, recreation center, market, hall, rest area and service desk etc. There are rooms on the first and second floors, including single rooms, double rooms and triple rooms. Stairs and passenger elevators are located in an entrance hall, and a staff elevator is located in the south. Suite, garden and offices on the third floor.



hotel 0F

-The basic characteristics of hotel

The center of the first floor of the mall is empty, connecting the road to the hotel from the parking building. In addition to the parking building on the west side of the shopping mall, there is also a row of parking spaces along the street. People who go to the shopping mall and hotel can choose here to park nearby. The mall is mainly a retail store and a restaurant, providing convenience to the people who come to the hospital and the surrounding neighborhoods and factories.

-The basic characteristics of hotel

The hotel provides accommodation for people who come to the surrounding area as well as a place for medical staff to rest.The hotel provides meeting rooms and multimedia rooms for business receptions and large events.

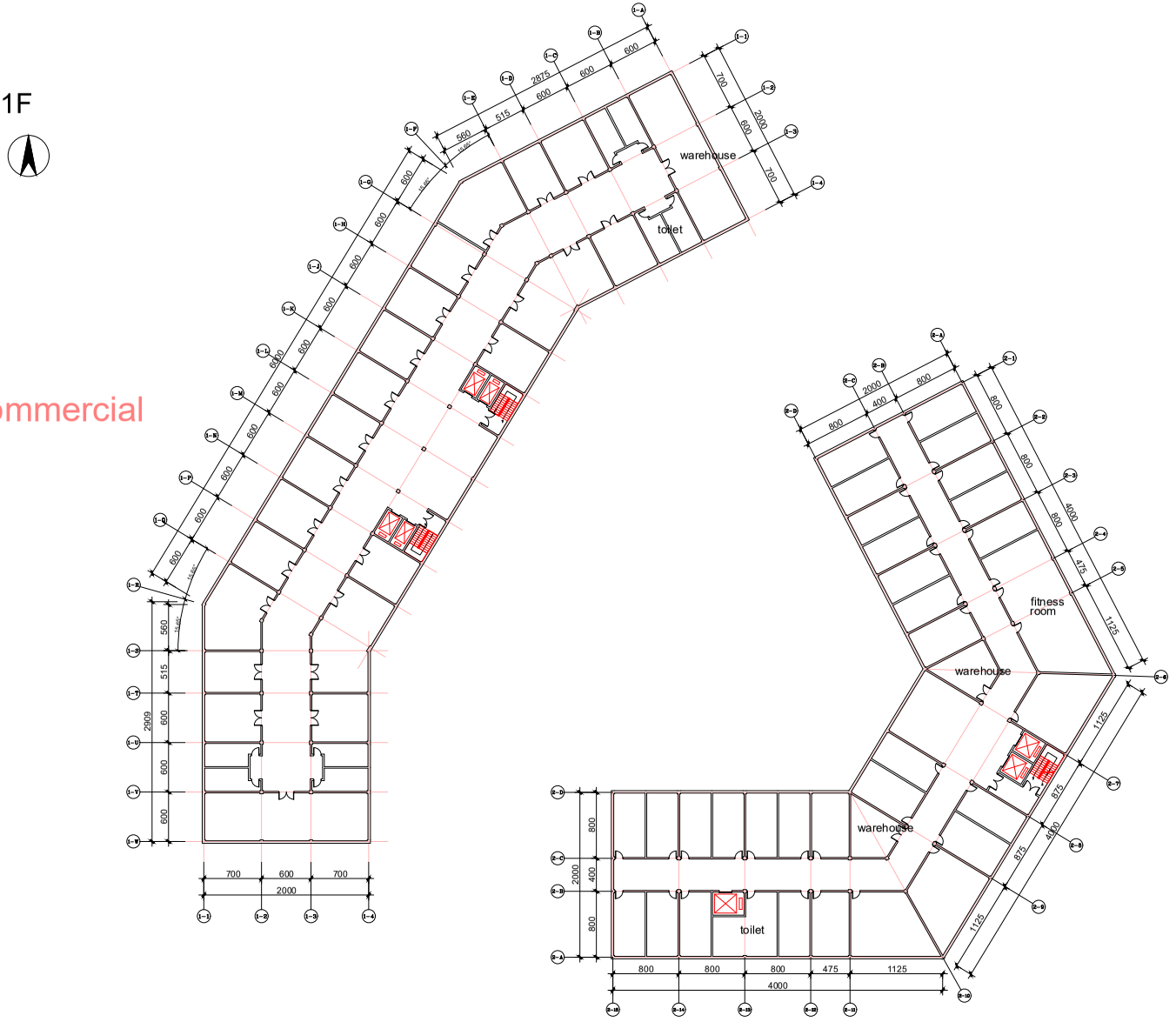
5.1.3 Each floor of commercial area plan

Commercial and Hotel 0F

0 5 10 15 20 25M

Commercial and Hotel 1F

0 5 10 15 20 25M



Commercial

Hotel
(Medical Dormitory)

Hotel 2F

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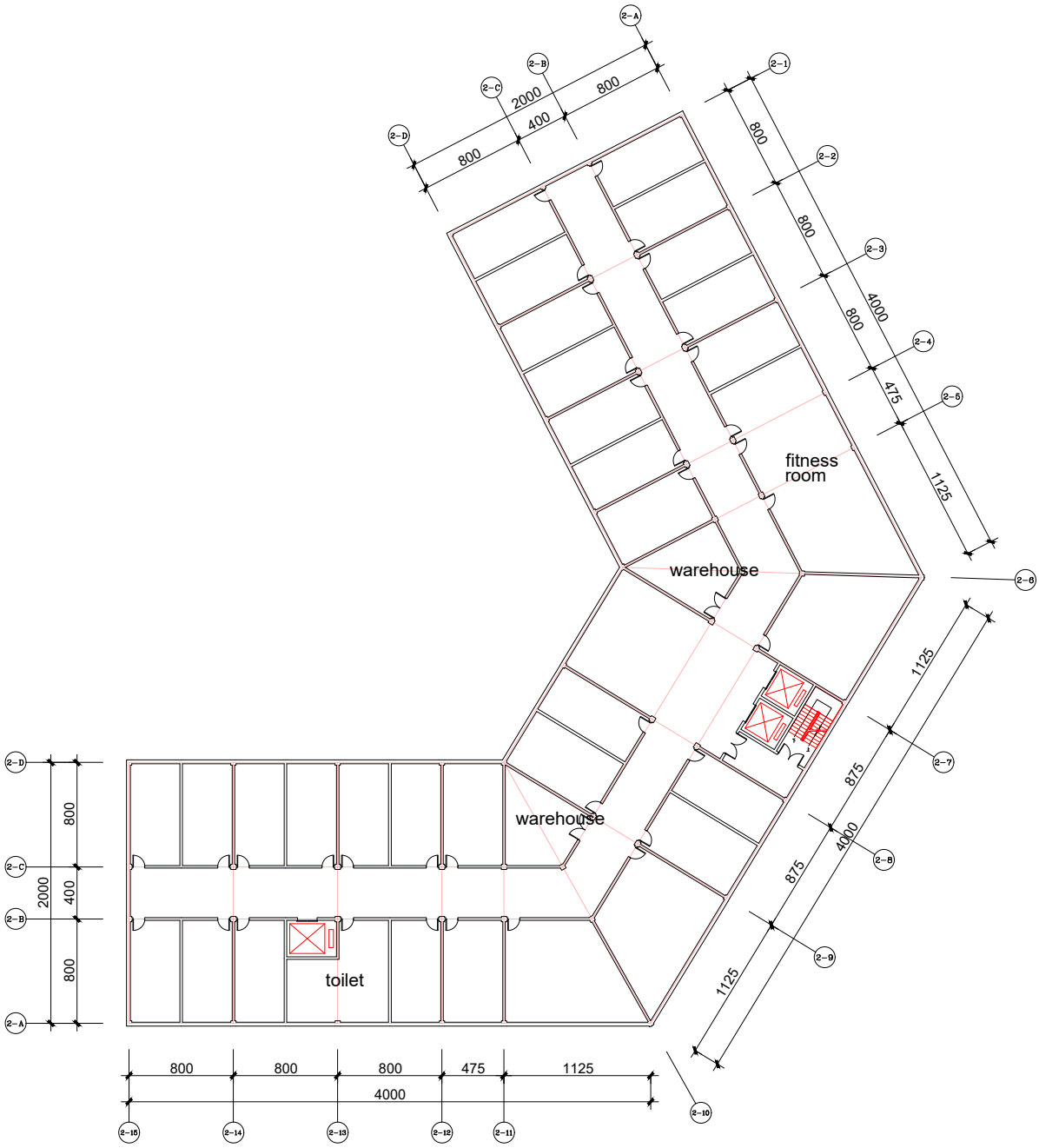

Hotel
(Medical Dormitory)

Hotel 3F

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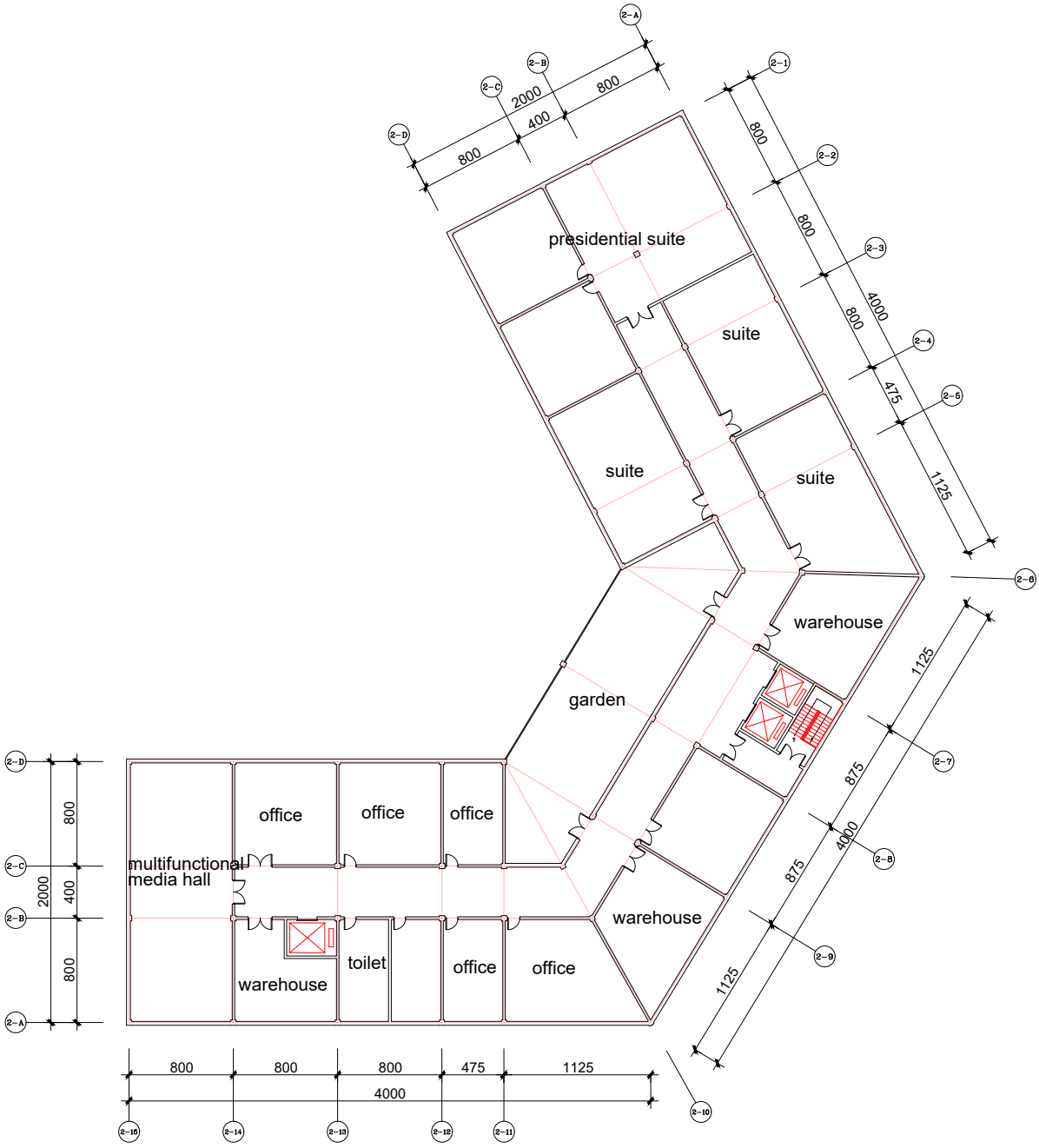
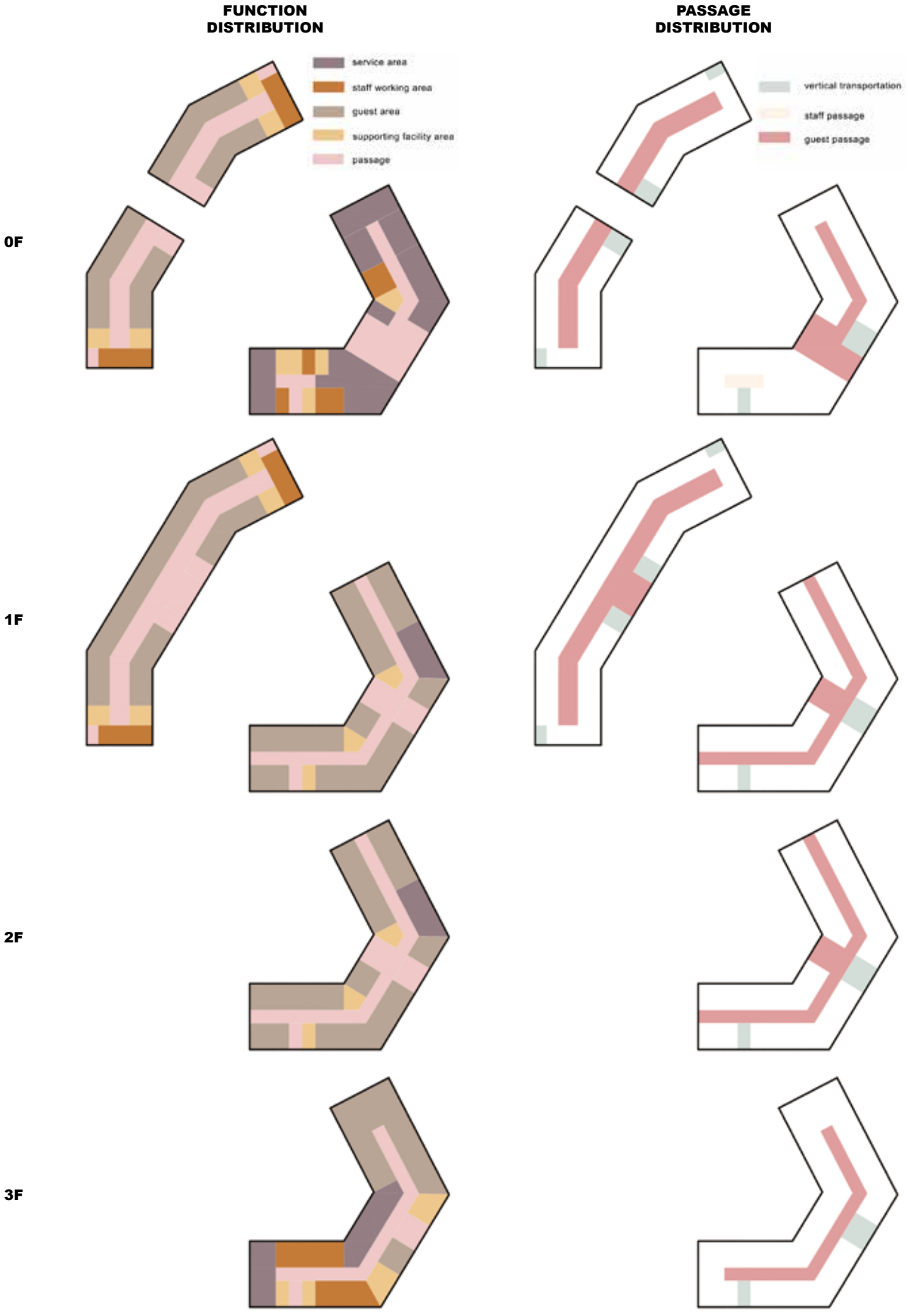


Hotel
(Medical Dormitory)

5.1.4 Each floor of commercial area function



5.2 Hospice care

5.2.1 The meaning of hospice care

Hospice care is not a cure, but rather a medical care focused on reducing the symptoms and slowing the progression of the disease in the weeks or months leading up to death. Hospice does not seek aggressive, potentially painful, or pointless treatment, but it requires skilled practitioners and good service to control the patient's symptoms.[43]

Hospice care is a new frontier interdisciplinary subject in the field of modern medicine, which is a symbol of social demand and the development of human civilization. Worldwide, it's only been around for a couple of decades.[43]

Hospice care, let life "go" warm.

Hospice care is a lofty cause in line with the interests of mankind, which is of great significance to the progress of human society:

> Hospice care is in line with the objective requirements of human pursuit of high quality of life. With the progress of human social civilization, people have put forward higher requirements on the quality of life and the quality of death. Send off, close the last page of life journey, draw a perfect full stop.In order to let the patient in the death of peace, peace, comfort, so that the family after the death of the patient did not leave any regret and shadow.
>
> Hospice care is a symbol of social civilization. Everyone hopes to live smoothly and die peacefully.Hospice care is a social public undertaking for the dignity and comfort of patients to reach the other side of life. It is a symbol of social civilization.
>
> Hospice care embodies the lofty medical professional ethics. The core content of medical professional ethics is to respect the value of patients, including the value of life and personal dignity; Hospice care through the implementation of holistic nursing for patients, with scientific psychological care method, superb clinical nursing means, as well as palliative, support therapy to maximize to help patients to reduce physical and mental pain, improve the quality of life, quietly go through the last stage of life. As the concrete implementors, medical personnel fully embody the noble professional ethics of medical care which aims to improve the value and quality of life.

5.2.2 Care content and care object

Care content:

> Body care: relieve pain through the care of medical staff and family members, and enhance body energy through a natural healthy diet.
>
> Heart care: through the establishment of the concept, it can reduce the psychological anxiety, fear, anxiety, complaint and care, so as to make them feel at ease, relieved, and full of hope and confidence in the future world (i.e. after death).

Spiritual care (considered as Taoist care in Buddhism) : to look back on life and seek the meaning of life, or to establish life values, such as eternal life, ascension to heaven, and going to the Western paradise, mostly through religious teaching and methods.

Care object:

I. Priority Objects: Seriously ill persons and their families; The elderly; Animals, etc.
II. Objects of positive aspects: School education; Adult education.

5.2.3 Hospice care area in project

Hospice care area in project

The hospice area exists in the auxiliary hospital department in this project, including a hospice center and two hospice wards. There are two inner courtyards in the middle, and hospice patients can directly see the courtyard scenery in the ward.

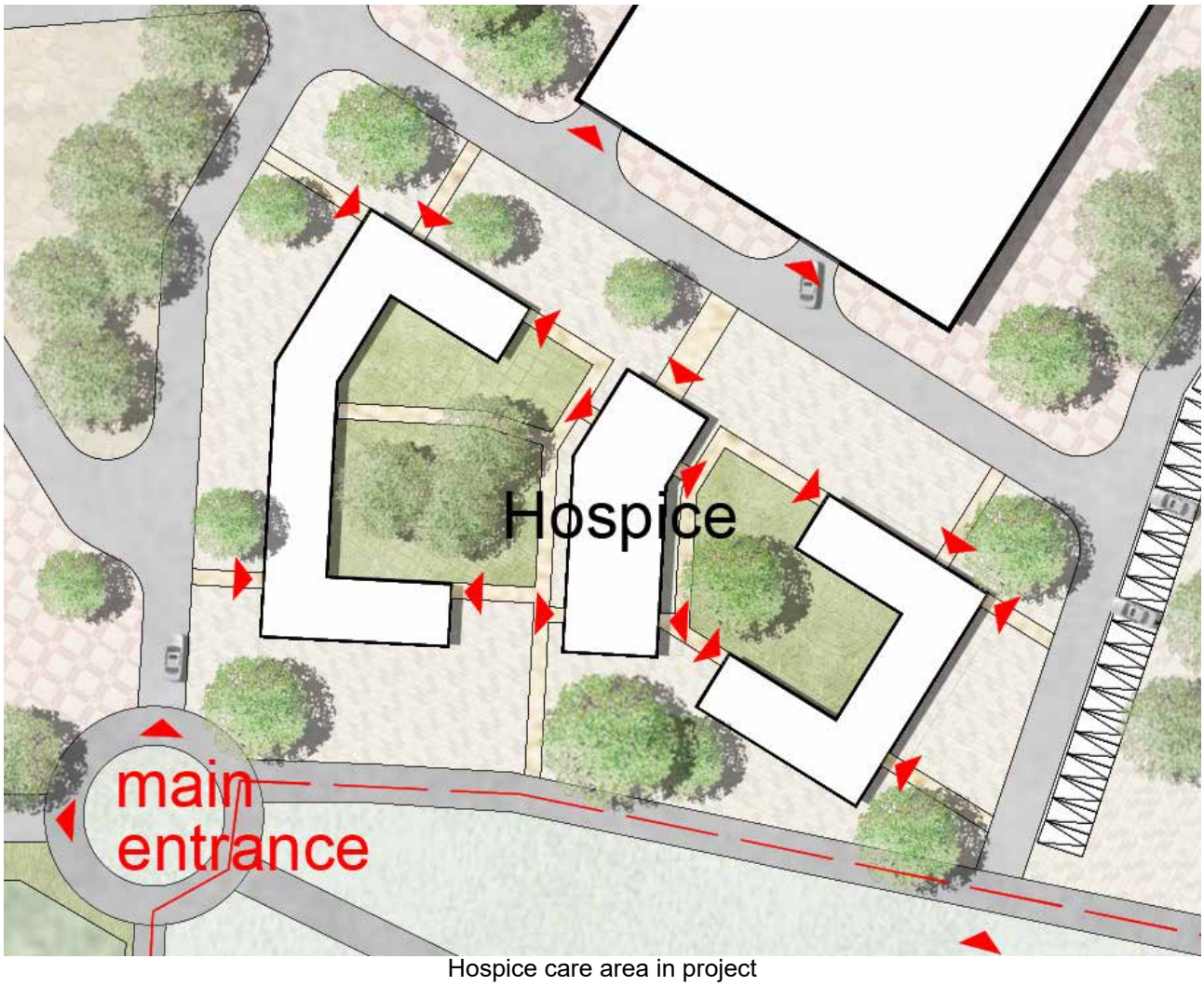
People can access the hospice care center in the middle from the ward areas on the left and right through the corridor, where they can have daily meals, simple treatments and participate in some activities.

The doctor's office and treatment room are also located in the central area. The wards on both sides are accompanied by nurse service stations, which can efficiently and conveniently deal with patients' emergencies.

Technical index:

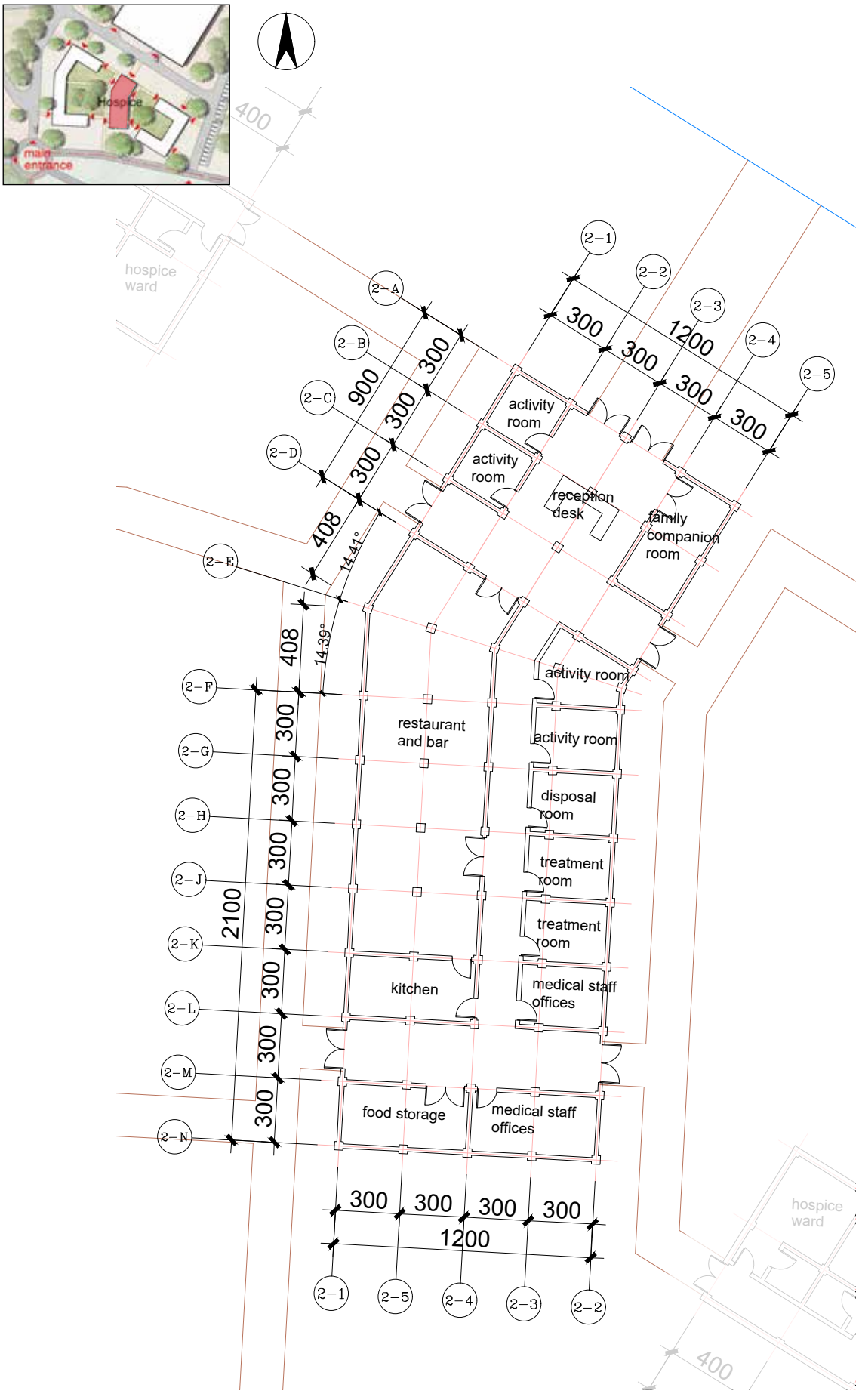
The hospice care center covers an area of 421 ㎡ , including reception desk area, family companion room, activity rooms, treatment rooms, disposal rooms, kitchen, restaurant, storage rooms and medical staff offices.

The area of the two hospice wards at the left and right of the center is 705 ㎡ and 512 ㎡ respectively. The large ward area has 15 hospice wards and the small ward area has 11 hospice wards. In addition, there are service stations, laundry rooms, and storage rooms.

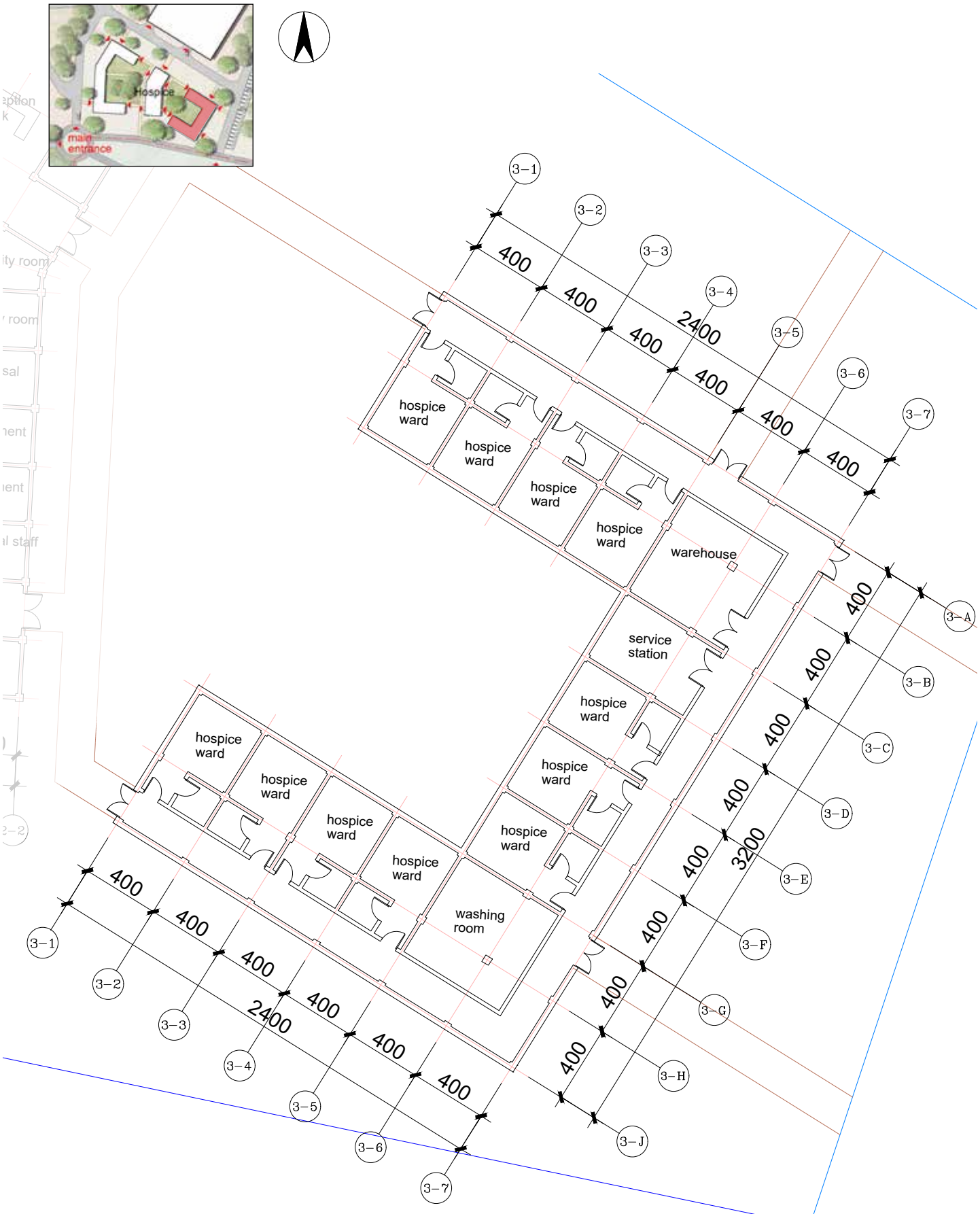


Hospice care area in project

Hospice care left wards 0F



Hospice care center 0F



Hospice care right wards 0F

5.3 Parking areas

5.3.1 Multi-storey parking building

Multi-storey parking building refers to a self-propelled parking building in a three-dimensional parking building, that is, a building used to store vehicles. There is a driveway in the garage, and the driver himself drives in and out of the garage. [44]

Its advantages are: it has all the advantages of indoor parking, such as a stable parking environment and high land utilization; centralized storage of vehicles is more convenient to manage; compared to the above parking methods, it can provide dozens of times or even more in places with more people. Hundred times the parking space; compared with mechanical parking buildings, the cost is lower and the technology required is simpler.

In addition to the above reasons, the parking building is set up in this project to quickly convert the parking space into a closed and isolated medical space in the future in an epidemic or other emergency situations, to provide greater help for emergency medical situations, and to deal with difficult public health crisis.

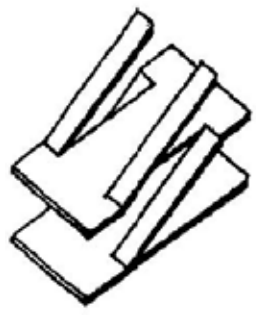
5.3.2 Summary of the characteristics of multi-storey parking buildings [45]

Advantage:
The construction cost of multi-storey parking buildings is low, operation and maintenance costs are low; the safety is high, the service life is long, and it can be used for secondary planning later.

Disadvantages:
The volume is huge and the service radius is large; the land area is slightly larger than that of the mechanical three-dimensional parking building, and the land cost is more than that of the underground parking lot. The poor treatment of vehicle noise and exhaust gas will affect the surrounding residents.

Conclusion:
Compared with the flat parking lot, the multi-storey parking building has a much higher utilization rate of land resources, the overall cost is low, the service life is long, and it can be used twice, and the maintenance cost is low. In and out, there is no hidden danger of mechanical transmission failure; generally there is a larger opening area, which is conducive to ventilation and lighting, which is the development trend of urban parking methods in the future.

5.3.3 The parking building in project

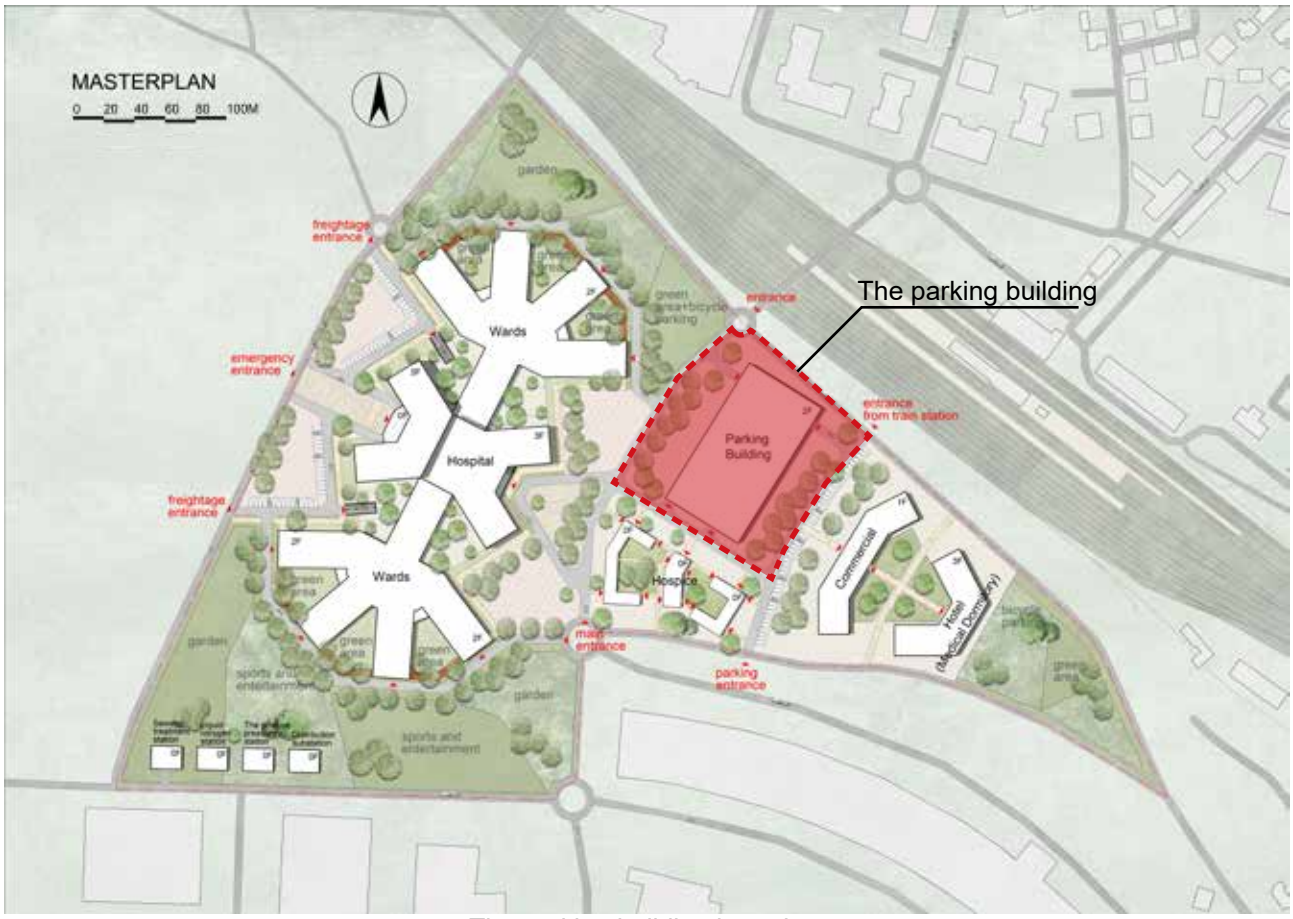


Long straight ramp

In this design, a long straight ramp is used, and ramps and connections are set between the two ends of each floor. The advantage is that the structure is simple, but the disadvantage is that there are relatively many parking spaces and the vehicles are turning in and out.

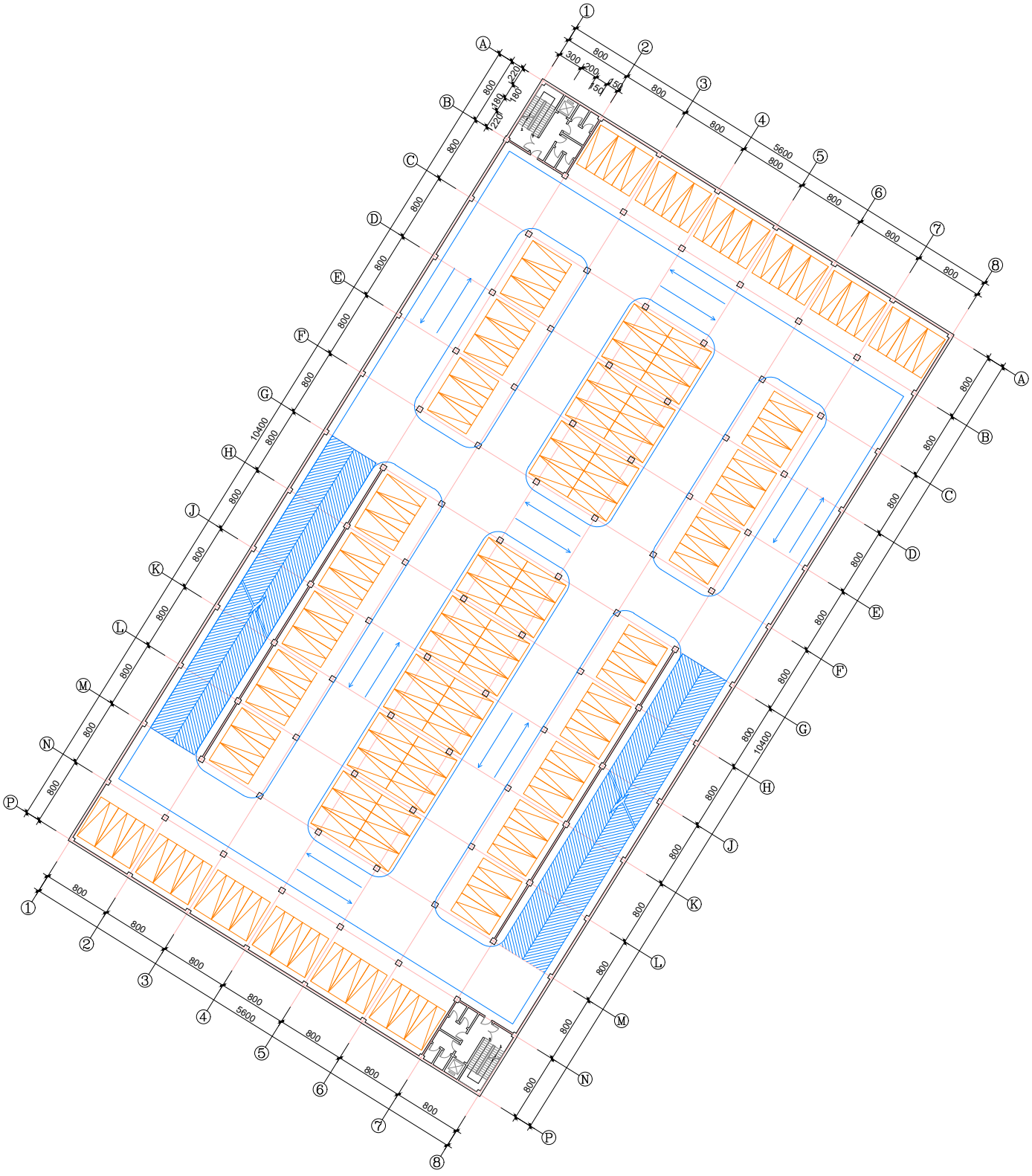
The parking building of the project is set up separately, located in the southeast of the hospital building. There are a total of 390 parking spaces. Each floor is equipped with

two up and down ramps, two stairwells and toilets. The plan is simple and there are four entrances and exits to connect to the hospital, hospice, commerce.

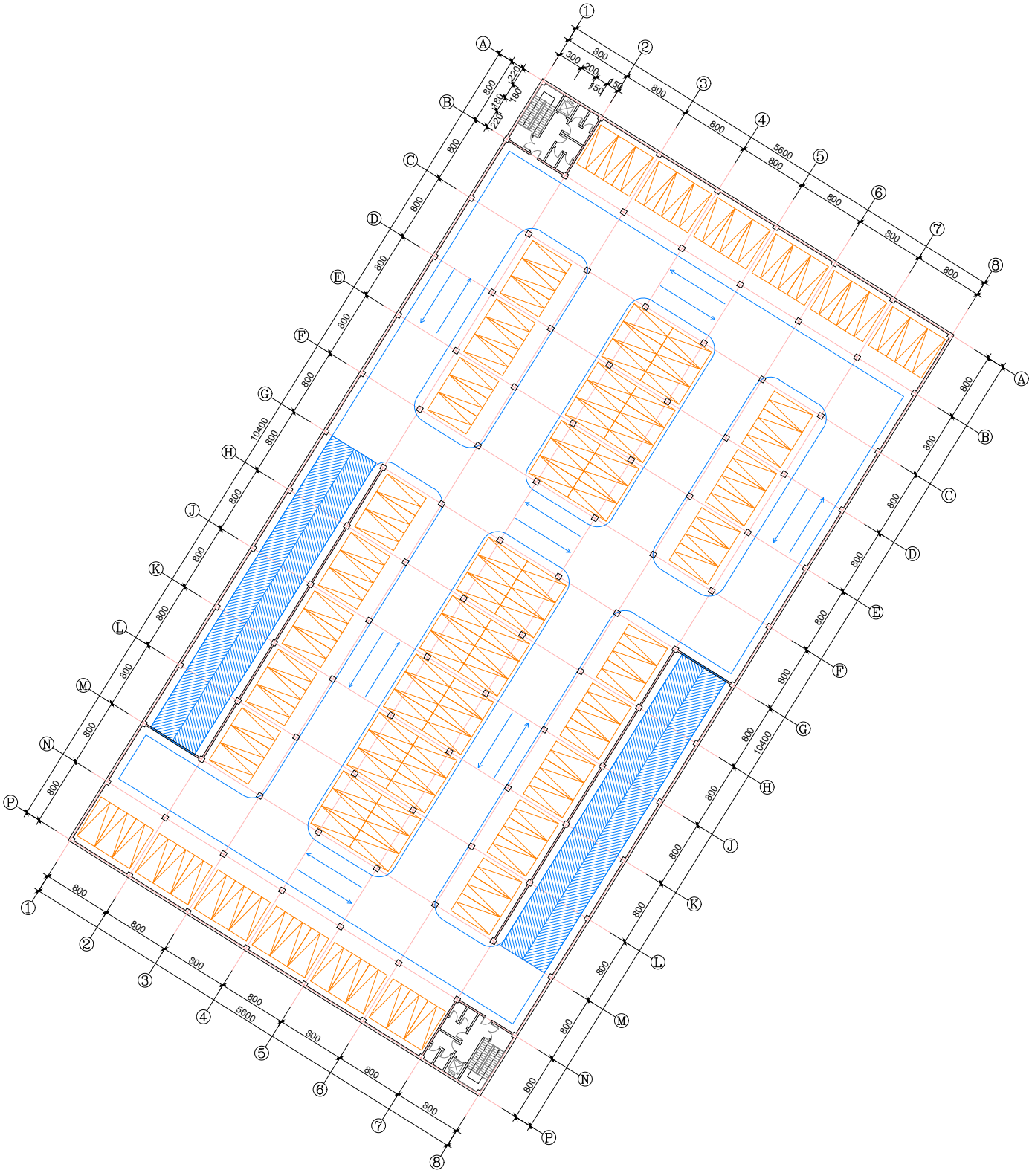


The parking building in project

Parking building 0F



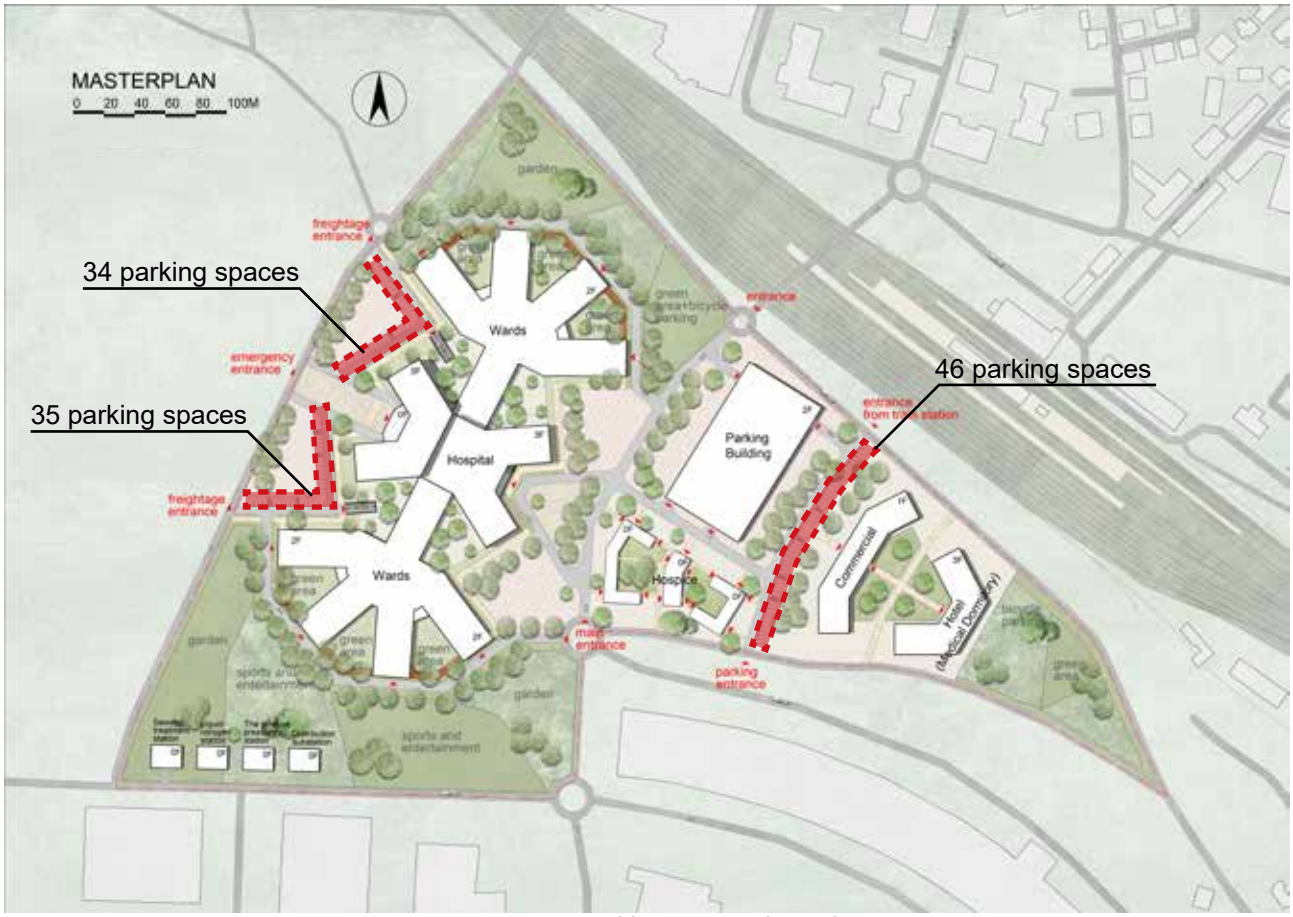
Parking building 1F



Parking building 2F

5.3.4 Other parking areas

In addition to the parking building, this design also sets up several on-street parking spaces. Located at the back of the hospital building, 69 on-street parking spaces are set up along the roadway at the entrance of the emergency department. In addition, 46 on-street parking spaces were set up on the side of the roadway between the commercial building and the hospice area.



on-street parking spaces in project

Chapter 6
Transition from General Hospital to Emergency Hospital

6.1 "Change" and "Response" for hospitals

6.1.1 Growth of medical demand

Due to the continuous increase of population, the continuous development of economy, the extension of life expectancy and the improvement of living standard, it turns out that people do not go to hospital for minor diseases and live in hospital less for serious diseases. Higher household incomes and increased health spending are now leading to an increase in outpatient visits and inpatient beds.

6.1.2 Changes in disease profile

Current infectious disease is a disease of the harm, the 20th century 60 s is fundamental in the nationwide control of infectious diseases, cerebrovascular, respiratory system disease, tumor increased as the main contradiction: with the improvement of people's economic level, and coronary heart disease, drug addiction, obesity, sexually transmitted diseases, etc., these changes will certainly bring hospital department of structure, area distribution and so on a series of changes.[46]

6.1.3 Development and update of medical technology and equipment

Medical equipment update faster and faster development, from the early biochemical inspection facilities, X-ray machine, clinical specimens, inspection and quarantine, simple equipment, a short few decades, a new type of medical equipment have sprung up, such as CT machine, ultrasonic transmitter and nuclear medicine chemotherapy related machine, NMR and so on diagnosis and treatment equipment, new equipment at the same time, the life is very short of upgrading faster.

At the same time, the number of specialized treatment departments for patients and surgeries is also increasing, which puts forward new demands on the old architectural model of hospitals

6.1.4 Changes of medical mode and hospital management mode

In the transformation of the overall medical science model, the old biomedical model has been unable to meet the requirements of current medical technology, and the nursing ward has become more mature, with more detailed items.

For example, in the aspect of maternal and child health care, the senior wards of the department of maternal and child care sharing the same room have been developed, and the internal space structure has caused adjustment and changes.

Modern information management mode will inevitably bring some impact on the original medical procedures, and it will also respond to the architectural space.

6.1.5 Variable evaluation

The growth and change process of a hospital also has certain biological characteristics, manifested in the metabolism of the hospital's technical equipment, the organic growth of various components, and the life process of the gradual aging of some functions of the hospital. The growth rate of hospitals will inevitably bring great pressure to the expansion of modern hospitals. At the same time, in the final analysis, hospital construction technology needs to continuously improve itself to meet the continuous update of medical technology requirements. Medical technology and equipment are developing rapidly. Hospitals have entered a continuous aging process, and hospital buildings need to be continuously rebuilt and expanded.

According to the statistics of building revisions of six representative large hospitals in Japan since 1997, the increase in beds has been the most obvious. With the expansion of hospitals and the increase in patients, the annual increase in bed requirements has reached 7.23%. At the same time, the overall area of the hospital is expanded about 0.58 times a year, and the total number of restructuring is about 25 times.[46]

The life of buildings can often reach a long time. The life of basic equipment such as the structure of the structure building and equipment pipelines, and the basic equipment such as equipment pipelines is not very long, but they can be updated frequently and there is no problem in maintaining normal functions. The construction life of the hospital is mainly affected by the use function. When the construction equipment cannot work normally, the construction life of the hospital will end, which is about 50 to 60 years. Therefore, the resilience of the hospital construction has an impact on the ultimate hospital construction. The service life has a great influence.

Therefore, the focus of modern hospitals is whether they have the ability to modify, expand and adapt to the requirements of functional transformation in the overall planning and design of hospital buildings, enhance their own adaptability, and extend the functional life of hospital buildings.

6.2 The temporary reconstruction plan of the first hospital of Zhejiang University

6.2.1 Emergency rehabilitation during the epidemic

Since December 2019, an outbreak of pneumonia infected by novel coronavirus broke out in Wuhan and quickly swept the whole China.

Since the admission of the first confirmed patient in Hangzhou on January 19, 2020, the first hospital of Zhejiang University has become the earliest provincial designated hospital to treat COVID-19 patients in Zhejiang Province.

Adhering to the principle of "concentrating patients, experts, resources and treatment" as required by the provincial Party committee and the provincial government, the first hospital of Zhejiang University launched the emergency support of Zhijiang Hospital as the designated hospital for the centralized treatment of COVID-19 patients, and undertook the important task of treating critically ill patients in the whole province.

From the New Year's eve to the third day of the first lunar month, Zhijiang hospital ward, ICU, emergency department, radiology department and other areas of the emergency renovation, only three days to create the "Zhejiang Leishenshan".

Up to now, the first hospital of Zhejiang University has invested more than 400 front-line medical staff to participate in the treatment, and the hospital has "zero infection", "zero missed diagnosis" and "zero death" of the patients.[47]

Zhijiang hospital of the first hospital of Zhejiang University [47]

Zhijiang Hospital of the First Hospital of Zhejiang University (hereinafter referred to as

Zhijiang Hospital) is a newly constructed hospital, located in No. 366 Wutong Road, Xihu District, Hangzhou, covering an area of 150 mu, with a building area of 179,000 square meters and 1000 beds planned.On November 1, 2019, Zhijiang Hospital just opened its outpatient clinic.

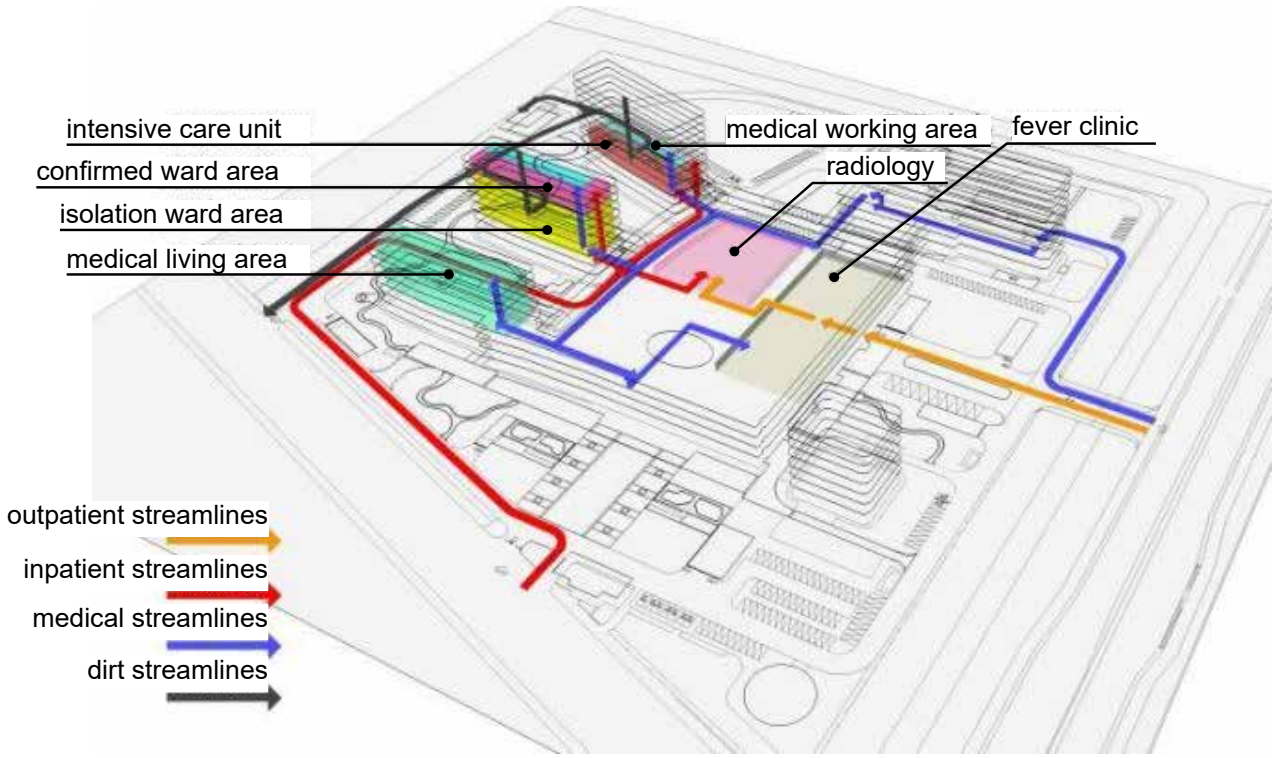
After receiving the task of COVID-19 patients, Zhijiang Hospital District immediately carried out rapid transformation of wards, ICU, emergency department, radiology department and other areas according to the requirements of hospital sense. Some of the transformation areas are described below.

The overall layout

According to the layout of Zhijiang Hospital, as shown in the figure below, we have managed the confirmed patients, suspected patients and medical staff in different areas. Emergency overall as fever outpatient service area, confirmed unified critically ill patients admitted to the 4 floor of ICU in No.5 building, diagnosed mild building unified patients admitted to the 7-9 floor in the No. 3 building, unified suspected patients admitted to 3-6 floor (1 per room) in No.3 building, No.2 building as medical staff living areas, ward as patient transport channel, the ground floor of the second floor of the whole campus as a clean channel, do not change the original sewage channels. [47]

Zhijiang hospital overall layout [47]

Patients with fever enter each fever outpatient office in the emergency department through the east gate; ambulances enter the patient elevators in each ward building through the south gate; medical personnel enter each diagnosis and treatment area through the clean channel on the 2nd floor of the No.6 administrative building; sewage is transferred from each sewage ladder to the sewage exit; the specific streamlines is shown in figure next page.

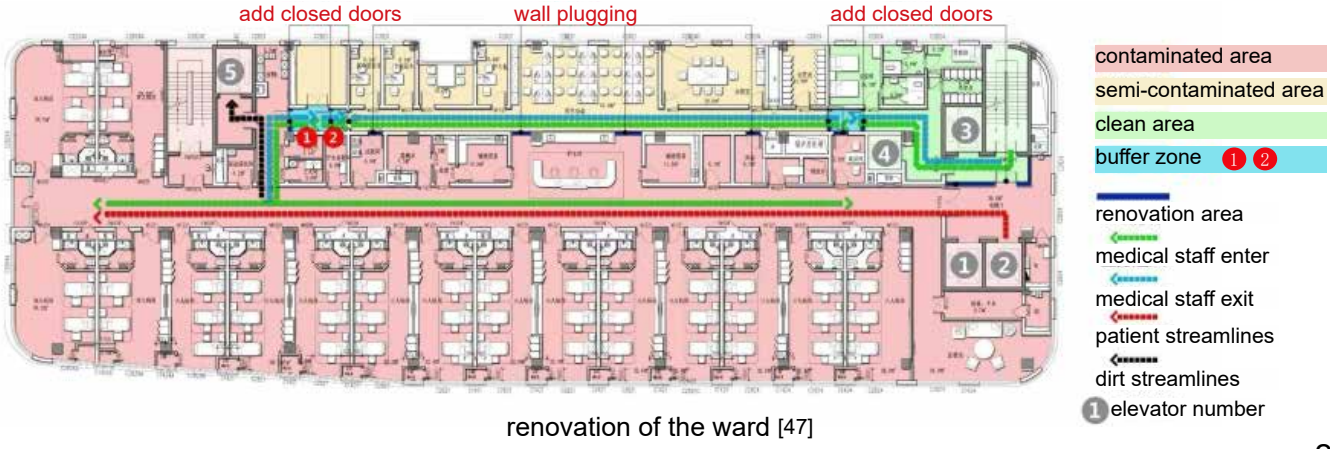


The streamlines of Zhijiang hospital [47]

6.2.2 Temporary renovation plan for standard wards

There are 44 beds on each standard floor of the ward building of Zhijiang Hospital, with 14 triple rooms and 4 double rooms. According to the requirements of hospital sense, the standard layer is divided into "3 zones, 2 belts, 2 passages" (contaminated area, semi-contaminated area, clean area, 2 buffer zone, patient passage, employee passage): partitions on both sides of the nurse station and doctor passage to the west Add two partitions to make 2 buffer zones, a partition on the east side of the doctor's passage to isolate the clean passage, and a safe passage at the entrance hall.

After the transformation is completed, the streamline diagram of medical staff and patients is shown in figure below: The medical staff enter the cleaning area of each floor of the ward from the doctor's elevator, and complete the changing work in the cleaning area (such as wearing hats, medical protective masks, protective clothing, Goggles, gloves, etc.) enter the potentially contaminated area (doctor's passage), then enter the buffer room from the potentially contaminated area and then enter each ward.



renovation of the ward [47]

After the medical staff complete their work, they change their outer gloves in the contaminated area and enter the buffer room 1, take off the outer gloves, protective clothing, and goggles in the buffer room 1, and then enter the buffer room 2, and take off the medical protective masks, hats, and caps in the buffer room 2. Inner gloves, after doing hand hygiene, enter the semi-contaminated area, and after showering and changing clothes in the shower room in the semi-contaminated area, enter the clean area from the elevator to the staff cleaning passage to ensure cleanliness and separation of pollution.

With the cooperation of the construction unit, the transformation was completed within one day according to the design drawings. After the transformation, the site pictures are shown in the figure below.

The real scene of the hospital ward after the renovation [47]

After the standard floor of Zhijiang Hospital was transformed into a COVID-19 admission ward for confirmed patients, 18 rooms were all double rooms with a flat layout, as shown in the figure below. The double rooms can avoid crowding, create a good living environment for patients, and do not cause a waste of medical resources.The standard rooms of the ward are equipped with independent washrooms, washing rooms, 24-hour hot water, etc.

double room ward plan [47]

single room ward plan [47]

Before the standard ward of Zhijiang Hospital was transformed into COVID-19 suspected patients, a detailed analysis of hospital perception streamline was carried out, which strictly followed the cleaning separation, and the original design drawings were deepened and on-site transformation was carried out. The transformation scheme was consistent with that of the ward with confirmed COVID-19 patients admitted.

The standard room on the standard floor of the ward building for suspected COVID-19 patients in Zhijiang Hospital is a single room. The plan is shown in Figure left. One room for one person is ensured to avoid cross-infection caused by two or more people living together.

The standard rooms of the ward are equipped with independent washrooms, washing rooms, 24-hour hot water, etc.

6.2.3 Emergency room converted into a fever clinic

The emergency area of the Zhijiang hospital area was transformed into a fever clinic, and the fever clinic was divided into "3 zones, 2 belts, 2 passages" (contaminated area, semi-contaminated area, clean area, 2 buffer zone, patient channel, employee channel) according to the requirements of hospital feeling. The drawings after the transformation are shown in figure next page.

The medical staff channel on the northwest side of the nurse station is divided into 3 partitions to isolate a semi-contaminated area and buffer zone. Medical staff enter the clean area from the east gate of the medical staff passage, wear hats, masks, gloves, goggles, protective clothing, etc. in the clean area, then enter the buffer room, and then enter the consulting rooms from the semi-contaminated area, and the employees leave and replace in the contaminated area Take off the outer gloves, protective clothing, goggles, hats, masks, inner gloves, etc. from the outer gloves to the semi-contaminated area, and then enter the buffer room to bathe, change clothes and enter the clean area. The flow diagram is shown in figure next page. [47]

streamlines of Zhijiang hospital emergency department transformed into fever clinic [47]

With the cooperation of the construction unit, the transformation was completed within one day according to the design drawings. After the transformation, the site picture is shown in pictures below.

Patients enter the consultation rooms through the east gate of the fever clinic, ensuring the separation of clean channels and contaminated channels.

The real scene of the fever clinic after the renovation [47]

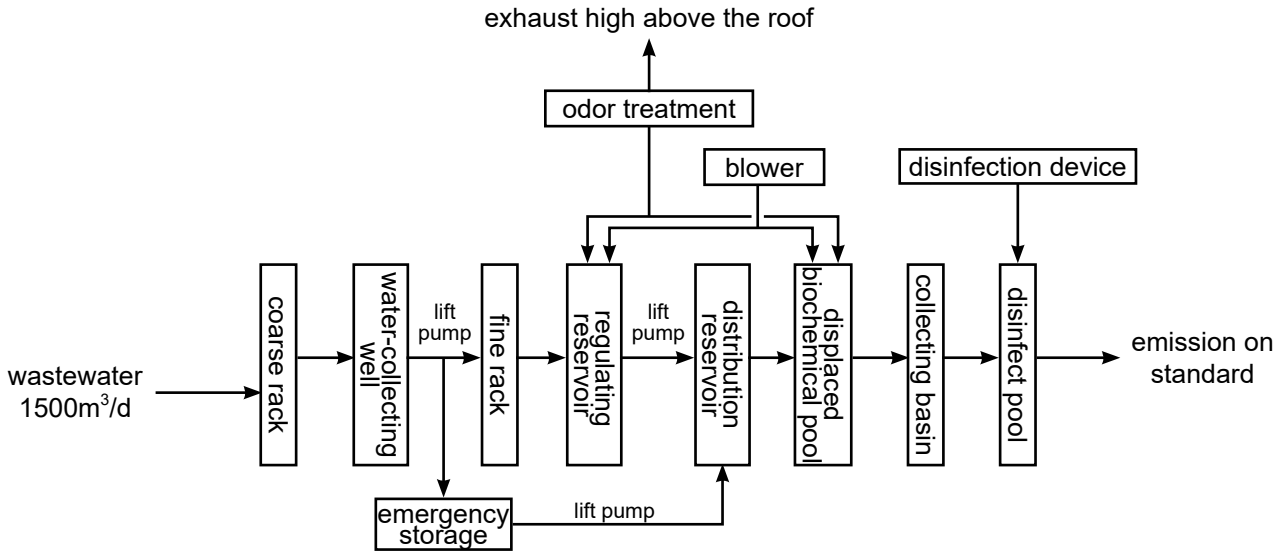
The main route of transmission of new coronary pneumonia is airborne, and confirmed patients become the source of infection. When a patient talks, coughs, or sneezes, the virus-containing droplets will be coughed out of the airway and hover in the surrounding environment. Normal people are easily infected when exposed to such droplets.

In addition, there is contact transmission, which refers to when people around contact with the living goods contaminated by the patient, they enter the respiratory tract through the hands, mouth, nose, and eyes to be infected. In order to block the source of infection, all air-conditioning, fresh air, logistics and other systems in the Zhijiang Hospital were shut down.

6.2.4 Covid-19 sewage treatment interim transformation experience

According to the *Water Pollutant Discharge Standard for Medical Institutions* GB18466-2005, the sewage discharge standard of infectious disease medical institutions is higher than that of general medical institutions, and general medical institutions with infectious wards should separate the sewage of infectious wards from non-infectious wards. The sewage and feces can be combined with other sewage for treatment after disinfection.

The sewage treatment process of Zhijiang Hospital is shown in figure below. The treatment scale is 1500 m³/d and the peak treatment capacity is 80 m³/h. After being treated by the sewage treatment station, it is directly discharged into the municipal sewage pipe network. *Water Pollutant Discharge Standard* GB18466-2005 pretreatment standard treatment. The size of the disinfection tank is 7m long, 3m wide, with an effective storage depth of 4m and an effective volume of 84m³. According to the maximum daily processing capacity of 1500 m³/d, the contact time in the disinfection tank is about 1.3h, which meets the standard requirements for the contact time of the disinfection tanks of comprehensive medical institutions, but does not meet the relevant standard requirements for infectious diseases.[48]



Flow chart of sewage treatment [48]

Zhijiang District calculated the water level of the collection tank and found that the amount of sewage produced was less than 200m³/d, and the residence time of the sewage in the disinfection tank exceeded 10h, and the ClO-ion could give full play to its oxidative properties for sewage disinfection.[48] Since the ward setting of general hospitals is not considered as infectious disease wards, and there is no corresponding pretreatment tank, in order to meet the requirements of the comprehensive medical institutions in infectious wards, sewage in infectious wards should be separated from sewage in non-infectious wards.

In accordance with the requirements of “Sewage and excrement in infectious wards can be combined with other sewage after disinfection”, chlorine injection equipment should be added to the septic tanks corresponding to the ward buildings and fever clinics, and disinfection pretreatment is carried out in the septic tanks. After the transformation, water samples are collected every day for nucleic acid detection of pathogenic bacteria and manual test of residual chlorine.

6.3 Enhance the strain capacity of hospital buildings

The purpose of the hospital's "change" lies in three aspects, either for the increase in quantity, the improvement of quality, or the rationality of order. The increase in quantity is mainly solved through expansion; the improvement of quality and the rational order are mainly solved through the internal adjustment, reorganization and transformation of the building space. [46]

In addition to meeting the needs of daily use and medical technology, the architectural design of the hospital must also meet the needs of building and equipment replacement. Sustainable development is the primary concept of the hospital’s architectural design. In addition to appropriately increasing the motorized area in the design, attention should also be paid Enhance the adaptability of hospital buildings to development and changes.

6.3.1 Select a construction base and planar body that is convenient and flexible for development

In addition to meeting the general requirements of the construction base, it is better to have two or three empty bases for the sustainable development of hospitals that are in need of future development.The size of hospital's strain capacity is closely related to its plane shape.

For example, in the traditional "H" character shape plan, medical technology in the middle, in the outpatient and inpatient contact body, before and after the barrier, no end, except to take the method of adding layer or transposition, it is difficult to develop.In the "E" shape plan, although the medical technology is still in, but because of the two ends, can be developed in two directions, can meet the needs of the expansion of the department. [46]

6.3.2 Select the module unit with strong adaptability

The reconstruction and expansion of the hospital is more restricted by the original base and the current situation. In addition to meeting the general requirements, the functional units of the hospital should also be short and compact, which can adapt to the requirements of different terrain and orientation.The choice of structural system needs flexible plan layout.

At present, the most commonly used frame, light plate frame and other structural types, to adapt to a lot of modern hospital medical technology departments, convenient to adjust the layout.

6.3.3 There is the possibility of adjusting the profile form and increasing the equipment layer

Many medical technical departments in modern hospitals, such as magnetic resonance room, digital subtraction apparatus, organ transplantation or operating room for cardiovascular use, all require a larger and longer continuous space, and the use of changable, convenient and flexible separation.

According to the present situation of our country, the medical technology department in order to adjust the plane function flexibly, mostly adopts the frame structure.

6.3.4 Set a certain flexible space

In terms of the design of hospital buildings, the space of the hospital needs to be designed flexibly, so as to make full use of the connection between spaces and give full play to the maximum function without wasting the limited space.

For example, in the past, the waiting hall and the middle courtyard are different from each other. Sometimes, there are many people queuing in the outpatient department, and the registration hall is very crowded. If the waiting hall and the middle courtyard are connected, the flow of waiting people can be dispersed, which is conducive to the order of the hospital and the management of waiting patients in the hospital.

6.3.5 Select a construction scheme that is easy to expand in stages

The structural plan needs to be determined to cater to the construction method.In addition, for the expansion method of the new and old buildings close together, window holes should be left or beams and columns should be used for load-bearing. If necessary, windows can be changed to doors, or partition walls can be removed in order to make the new building and the old building. Or the old equipment lines can be connected freely. When removing the partition wall, it is necessary to pay attention to the issue of the staging line. The staging line is located at the turning line of the plan change in architecture, and the same should be done in the change of the facade.

6.4 Transformation of emergency medical facilities under public health emergencies

6.4.1 China's COVID-19 emergency medical facility design standards

New emergency medical facilities consider rapid construction, health and safety isolation, and reduce environmental impact, and require:

I. Municipal conditions such as power supply, water supply, information network, medical gas, sewage discharge and so on for the construction of infectious disease hospitals can be in place in time.
II. The emergency facilities are transported by special ambulances, and the location is convenient for the ambulance to reach.
III. Set up a safety isolation area to prevent the spread of the new coronavirus to the surrounding environment and pollute the surrounding environment.

National Health Commission's"*New Coronavirus Infection Pneumonia Diagnosis and Treatment Plan (Trial Fourth Edition)*" Since December 2019, Wuhan City, Hubei Province has successively discovered multiple cases of new coronavirus infection pneumonia patients. As the epidemic spreads, in my country cases have also been found in other regions and abroad. The disease has now been included in the "*People's Republic of China's Infectious Disease Prevention and Control Law*" as a Class B infectious disease, and measures have been taken to prevent and control Class A infectious diseases.[49]

Epidemiological characteristics: At present, the main source of infection is the pneumonia patients infected by novel coronavirus.Respiratory droplets are the main route of transmission, but can also be transmitted by contact.An impressionable person is usually impressionable.The elderly and people with underlying diseases are more likely to develop the disease after infection, as are children and infants.Therefore, air transmission is considered to be the main route of transmission.

For the renovation of existing buildings, select independent buildings or the ends of existing buildings, and have independent entrances and exits to facilitate the control of the new coronavirus from spreading to adjacent buildings or other areas. The emergency medical process has special requirements for building space and equipment and facilities, and the renovation of existing buildings should be determined after pre-evaluating the conditions of facility renovation.

The architectural function layout of emergency medical facilities has a clear correspondence with medical content, and the scale and proportion of corresponding functional areas are set according to medical functions.

Due to the relatively independent location of emergency medical facilities, it is necessary to conduct hygienic isolation and observation of medical staff, and to build shift dormitories and living quarters.

In emergency medical facilities, due to the addition of shift living areas for medical staff, a new semi-clean area is added according to the health and safety level, which refers to the general activity area and material supply area for medical staff. In order to prevent pathogens from contaminating and spreading, set up corresponding sanitary passage and buffer rooms in accordance with medical operating procedures.

The main route of transmission of COVID-19 is air droplet transmission, and there is also the possibility of human-to-human transmission, body fluids and excrement transmission. In order to prevent polluted air from contaminated areas from flowing back to semi-polluted and semi-clean areas, causing infection of medical personnel, building doors , windows and other building components must be installed strictly in accordance with the unidirectional airflow direction.

The transmission route of COVID-19 includes contact transmission. In order to prevent pathogens from being infected in emergency facilities due to overlapping activities and traffic routes, it is necessary to strictly limit the areas of different populations, the flow of people, and the logistics, and avoid each other.

In order to prevent the virus from spreading to the outside world, all wards are negative pressure wards. Suspected patients cannot be judged whether they are infected before diagnosis. From the perspective of protection and safety, they should be in a separate room to avoid mutual infection. The confirmed patients have been confirmed to have the virus and there is no mutual infection problem, so double rooms can be used. Patients with complex illnesses, critical illnesses or patients with super-transmission characteristics should be alone in a single negative pressure isolation ward, increase the frequency of ventilation to avoid disturbing other patients and reduce the risk of infecting medical staff.

In order to prevent the virus from infecting medical staff through contact, meals, medicines, etc. provided to the patient when the patient can move on their own, are passed through the double-door airtight linkage transfer window to avoid contact and air backflow.

Medical waste contaminated with the new coronavirus has a strong potential for transmission, and the transportation process must be kept sealed. According to the requirements of the Center for Disease Control and Prevention, unified disposal.

The architectural layout of emergency medical facilities is mainly single-storey. In order to prevent air transmission, the distance between buildings is appropriately enlarged, which results in some related medical functions being far away. In order to take care of frail patients for medical examination or treatment, consider using battery carts to transport patients. In order to prevent the droplets sprayed from the mouth and nose of the patient from reaching the medical staff during patient transfer, the transfer bed is equipped with a protective cover that covers the patient's head . The width and slope of the road of the transfer route should meet the requirements for use.

The body of ambulances and patient transfer facilities may be contaminated with COVID-19 when transporting patients. To prevent the spread of the virus and contaminating medical staff in facilities such as ambulances, it must be decontaminated after the patient is transferred.

Emergency medical facilities can be constructed quickly and on a large scale through prefabricated construction, and suitable lightweight construction materials can be selected for some special functions such as medical technology to meet the requirements of internal medical procedures.

In order to prevent COVID-19 from sticking on the inner surface of the building space or infiltrating into the material, causing contact infection or spreading to adjacent spaces,

buildings with pollution risks need to be disinfected and scrubbed frequently.

Emergency medical facilities first consider the rapid and efficient realization of medical functions. Electromechanical facilities and equipment need to be adapted according to the building materials, building structure, construction method and building space pattern selected by the facility, and the installation and wiring meet the convenience, stability and practical use. Safety, which includes safety in use, sanitary safety and fire safety.

In order to prevent COVID-19 from spreading through the air flow from the leaky gaps and holes in the building to the adjacent space environment, it is necessary to seal the parts where various electromechanical pipes and wiring pass through the building walls, floors, and ceilings.

6.4.2 Establishment and management of isolation wards

6.4.2.1 Set up a nursing team for emergency observation ward

For example, setting up an emergency medical team on a temporary basis. The members were the nursing staff of the day surgery center, and their average age was (50.0 + 3.8) years old.Experience in operating room, surgery or gynecology nursing;1 nurse, 3 in charge, 1 chief nurse. [50]

6.4.2.2 Organize the training

Organize team members and related personnel to learn official documents about COVID-19 and familiarize them with the infectious characteristics of COVID-19 patients;By referring to the experience of emergency management of the ward during the SARS period, the medical staff should be trained on the knowledge of wearing protective objects to improve their protection awareness and protection skills.To fully predict the possible risk events in the post-nursing work of COVID-19, such as the treatment of patients' excrement, and standardize the treatment process: to conduct the drill of first aid plan and to conduct the emergency treatment for patients with sudden dyspnea in the way of scenario simulation;Do a good job of information security pre-control, not to spread information about suspected patients admitted to the ward.

6.4.2.3 Scientific layout planning, reasonable partition configuration

The transformation of the original day surgery center into an emergency observation ward requires full consideration of the overall layout of infectious disease protection zones. The emergency observation ward is arranged according to the pattern of the respiratory infection ward, with contaminated areas, semi-contaminated areas, and clean areas; set up pedestrian and logistics channels, and clearly mark clean and dirty channels; set up buffer areas, and configure mobile water hand washing devices ; Set up 5 unit rooms, and

each unit room is equipped with a simple doorbell, and marked the room number.
6.4.2.4 The configuration items in the unit room

I. Necessities for medical diagnosis and treatment: thermometer, stethoscope, life monitor;
II. Life necessities: mobile toilet, kettle and appropriate amount of mineral water;
III. Patients personal protective equipment: disposable slippers, disposable masks and hats, appropriate amount of paper towels, yellow garbage bags and quick disinfectants, etc.;
IV. Prepare a simple patient education manual for COVID-19, including pictures of cough etiquette, diagrams of scientifically wearing masks, diagrams of hand washing, pictures of nutrition and rehabilitation, etc.

For the placement of items in the emergency observation ward, refer to the item placement in the hotel, the design list of items and the schematic diagram of the simple use method; compare the manual of the portable toilet, print a digital iconic use method, follow the use steps, and paste 1-2 -3 and other signs. Orderly set up telephone communication equipment in contaminated areas and clean areas to ensure timely transmission of internal and external information; public medical equipment and disinfected items are placed in suitable and fixed locations. After the emergency observation ward has been rebuilt, the director of the hospital infection office, the director of the nursing department and the director in charge will conduct an on-site evaluation. After the evaluation is complete-the re-evaluation is qualified, the use can be approved, and the suspected patient isolation ward will be activated within 12h. Patients infected with COVID-19 are all isolated in single rooms.[50]

6.4.3 Reconstruction of isolation and admission wards

6.4.3.1 Site selection

Engineering control is an important part of infectious disease prevention and control measures. However, the architectural layout of the general ward of the general hospital cannot meet the requirements of the isolation ward for the treatment of patients with new coronavirus pneumonia. It is a fast, economical and feasible plan to select the ward with some conditions in the general hospital for renovation.

Wards in general hospitals can be roughly divided into two categories according to different passages. The first type of structure is the wards on both sides of the middle corridor. There are connected balconies outside the wards. There are passages at both ends. The passages have elevators or stairs leading to the first floor, as shown in Figure 1. The second type of structure is wards on both sides of the middle corridor. There are no balconies outside the wards or there is no connection between the balconies. There are passages at both ends, and the passage has elevators or stairs to the first floor, as shown

in Figure 2.

The first-class structure of the ward is the first choice for emergency reconstruction, and the second-class structure is the candidate. For the transformation of both types of structures, ward areas with elevators at both ends or elevators at one end should be selected.

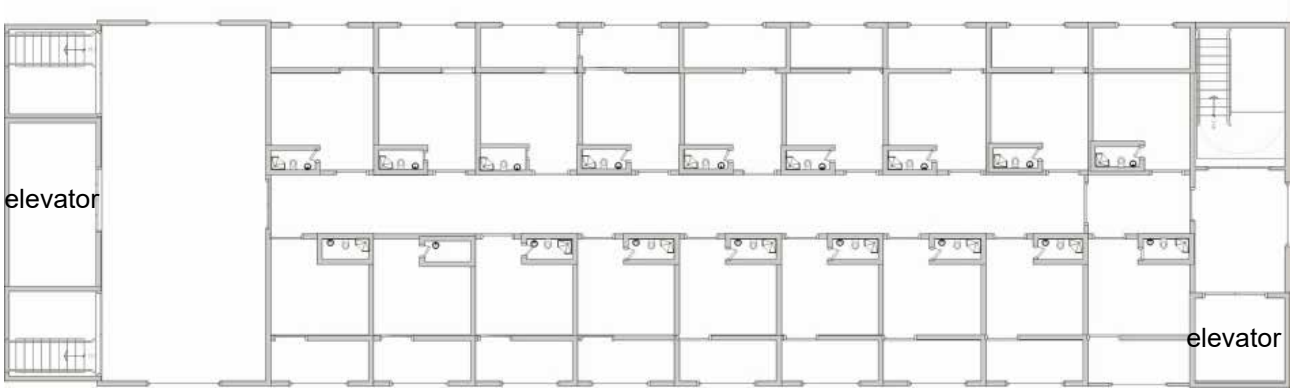


Figure1-Layout diagram of wards of the first structure type before reconstruction [51]

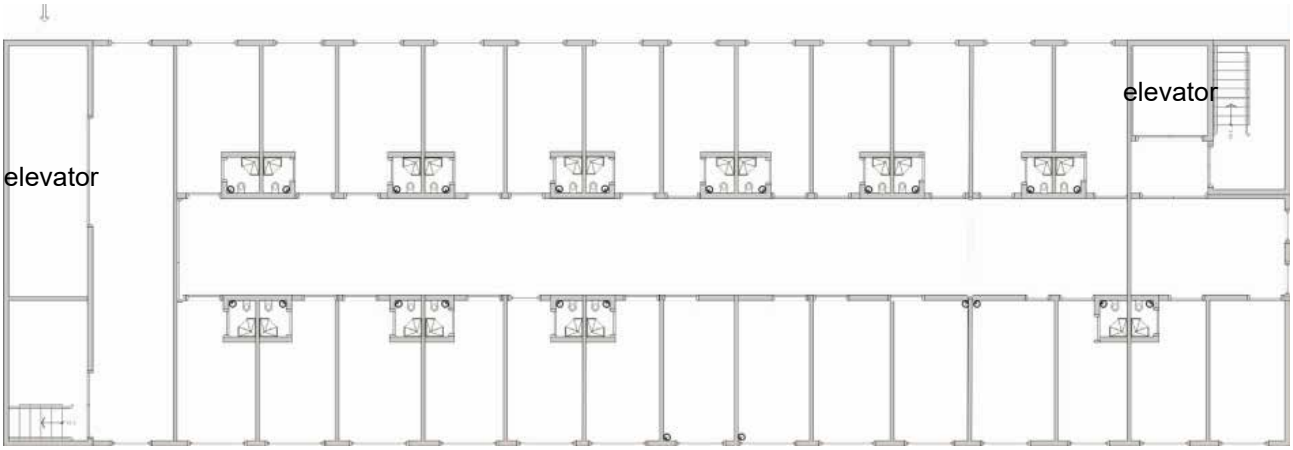


Figure2-Layout diagram of wards of the second structure type before reconstruction [51]

6.4.3.2 Transformation plan

Reconstruction of the first type of structural ward: one end of the ward is set as a passage for medical staff, and the other end is set as a passage for patients. The middle corridor is transformed into a buffer room between the potential contaminated area and the clean area on the side of the medical staff passage. The potentially contaminated area is transformed into a buffer room between the potentially contaminated area and the contaminated area by the side of the patient's passage; the balcony outside the ward is connected as an outer corridor, and the part of the outer corridor is connected to the medical staff passage by the medical staff passage, which is transformed into a clean The buffer room between the area and the potentially contaminated area or the contaminated area, the part of the outer corridor by the patient passage is connected to the patient passage as a contaminated area, and the middle is partitioned by a solid wall. The layout of the ward after the transformation is shown in Figure 3.

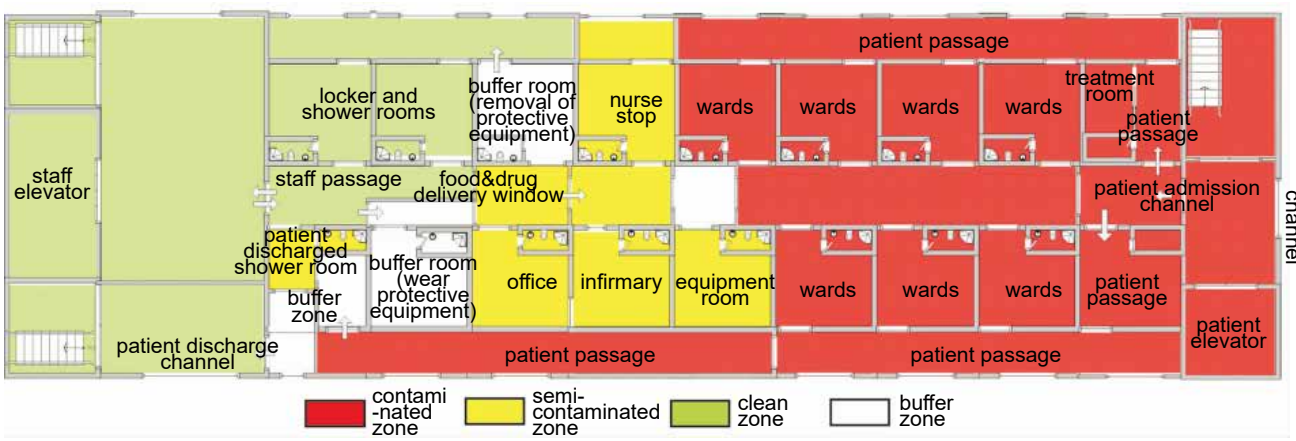


Figure3-Layout diagram of wards of the first structure type after reconstruction [51]

Reconstruction of the second type of structural ward: set one end of the ward as a passage for medical staff and the other end as a passage for patients. Several wards are opened and transformed into passages for medical staff and clean areas, and the middle corridor depends on the passage for medical staff. The part of the corridor is transformed into a potential pollution area, and the part of the intermediate corridor that depends on the patient passage is used as a pollution area. The layout of the ward after the transformation is shown in Figure 4.

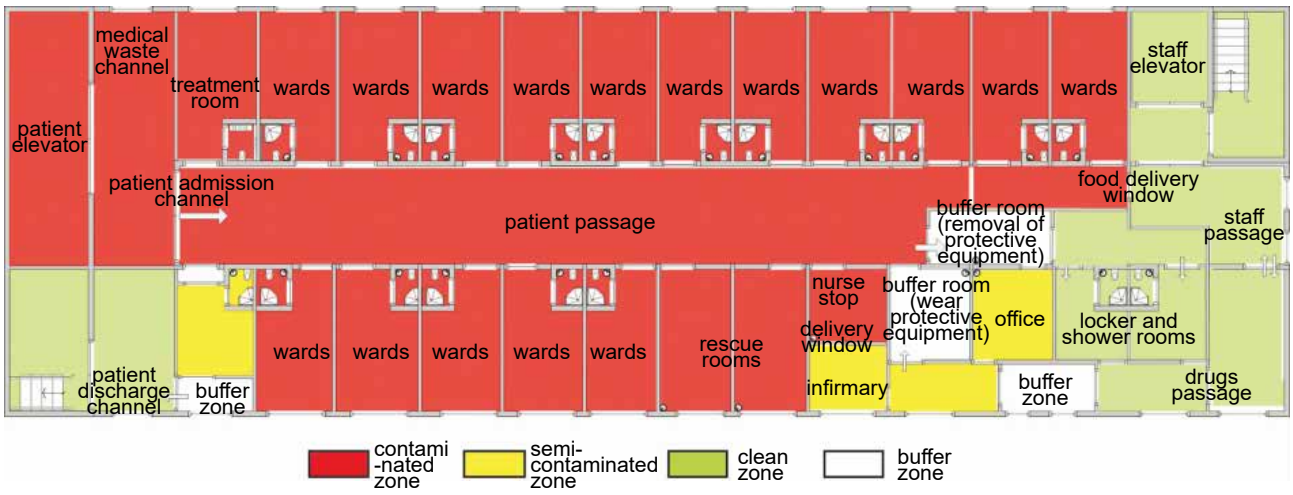


Figure4-Layout diagram of wards of the second structure type after reconstruction [51]

6.4.3.3 The conclusion of ward layout reconstruction

The emergency renovation plan during this epidemic is based on the existing building layout and designed according to local conditions. The layout is basically reasonable. The clean area, the potentially polluted area, and the polluted area are clearly divided, and the clean area and the potentially polluted area, the potentially polluted area and the polluted area There are physical barriers in between and buffer rooms, which can effectively block the flow of polluted air to the clean area and the potentially polluted area. It basically meets the principles of separation of cleanliness and separation of medical staff and patients. Medical staff reach the ward through the staff elevator in the clean area. The front hall

enters the working area of medical staff through the second change of clothes, and finally enters the ward area; while the patient enters the ward area directly through the exclusive elevator in the contaminated area through the dirty corridor.

The first type of structural ward transformation is the first choice. Its advantage is that there is basically no need to destroy the original room structure, the patient channel is completely separated from the medical staff channel, and there is a buffer front room between the medical staff corridor and the ward[1], additional project Simple and disassembly and assembly can be carried out simultaneously, the amount of plates is small, the cutting is simple, and the transformation is quick, but it is necessary to open the balcony partition walls of most wards and rooms, and the amount of work is relatively large.

The second type of structural ward transformation is an alternative. Its advantage is that only the part of the ward needs to be transformed. The amount of wall removal is relatively small, but the damage to the room is large. It is necessary to remove the partition wall of several wards. It is more complicated, the disassembly and assembly can only be carried out in order, the amount of plates is large, the cutting is complicated, and the transformation takes a long time, resulting in the small area of the functional room after the transformation, and the problem of wards without toilets. However, setting a room without a bathroom as a rescue room for critically ill patients may not affect the use. In addition, the nurse station is located in the contaminated area, and the shortcomings can only be remedied by management means. For example, before medical staff conduct diagnosis and treatment activities, patients should stop passing through the middle corridor, and start diagnosis and treatment activities after disinfection of the middle corridor. For the above two renovation plans, it is necessary to fully communicate with the logistics department before the renovation construction on the bearing wall of the house, water and electricity and other issues.

Through the transformation, although the layout of the ward cannot fully meet the architectural design requirements of the hospital ward for patients with new coronavirus pneumonia, it can basically meet the urgent needs of isolation and admission of patients with new coronavirus pneumonia during the epidemic period, and avoid cross-infection between doctors and patients to the greatest extent. Since the implementation of the transformation is economical and fast, the timeliness is guaranteed, and after the epidemic, it can be quickly transformed into a general ward, reducing the economic burden of vacant wards. The original ordinary medical room that meets certain conditions is selected to be transformed into an isolation ward. Its economic value and practical value have been effectively verified in the new coronavirus pneumonia epidemic, which has played a positive role in epidemic control. It is of great significance to promote the improvement of the city's major epidemic prevention and control system, and to improve the city's public health emergency diagnosis and treatment system.

6.5 Plan modification in case of emergency situation

One of the main problems discussed in this paper is how to transform the general hospital into a hospital that fits the layout of the infectious disease hospital, can accommodate the infectious disease patients and solve the hospital bed shortage when the large-scale infectious disease comes.Based on the case study of the first chapter and the case study of Leishenshan Hospital in the second chapter, the design of Trofarello Hospital adopts a modular and symmetrical design, which is convenient for the future reconstruction of the hospital for infectious diseases. The hospital can accommodate infectious patients without affecting its opening to ordinary patients.

When modifying the plane, we follow the following principles:
1. Try not to change the layout of the hospital, and do not delete or add too many doors and walls.

2. The complete separation of functional areas between general hospitals and infectious disease hospitals must be ensured.

3. Must ensure that the medical staff healthy, correct streamline, to avoid infection.

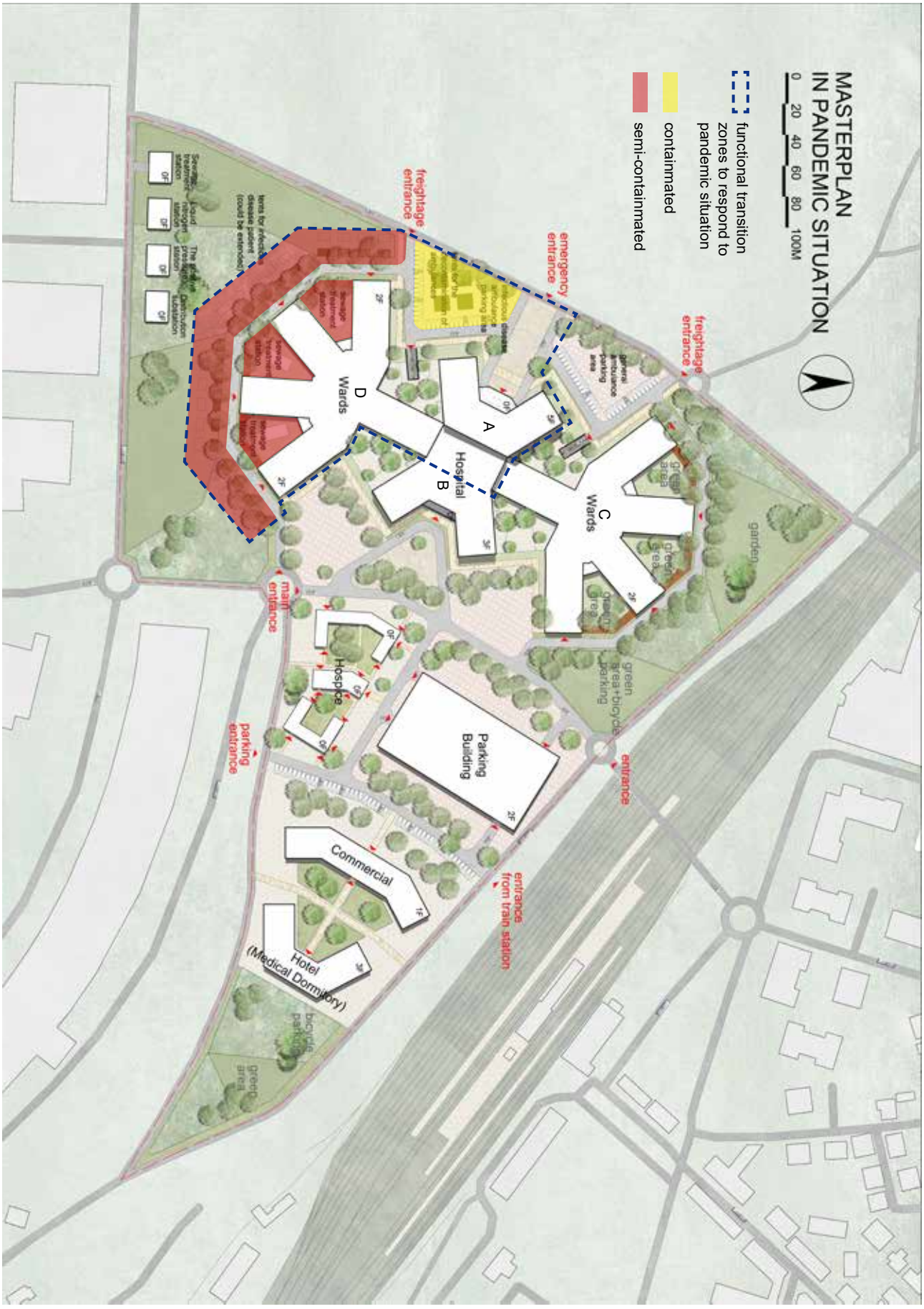
4. Pay attention to the flow lines of patients, medical staff and visiting family members in the infectious disease hospital, and avoid cross-infection.

6.5.1 Masterplan modified

As shown in the figure, hospitals for infectious diseases in emergency situations are in the blue box, which are used for the treatment of infectious diseases, while other hospitals that are not in the blue box are general hospitals.

Outside the hospital, half of the car park used for ambulances has been taken over for ambulances used to transport infectious disease patients. Four tents were built in the parking lot for cleaning the ambulances.

In the southern part of the plot, there were previously green spaces, fitness area and entertainment area that could be erected on top of which to treat infectious disease patients during an outbreak. And in the middle of each unit is a place to dispose of medical waste, which can be pulled along the road to the hospital.

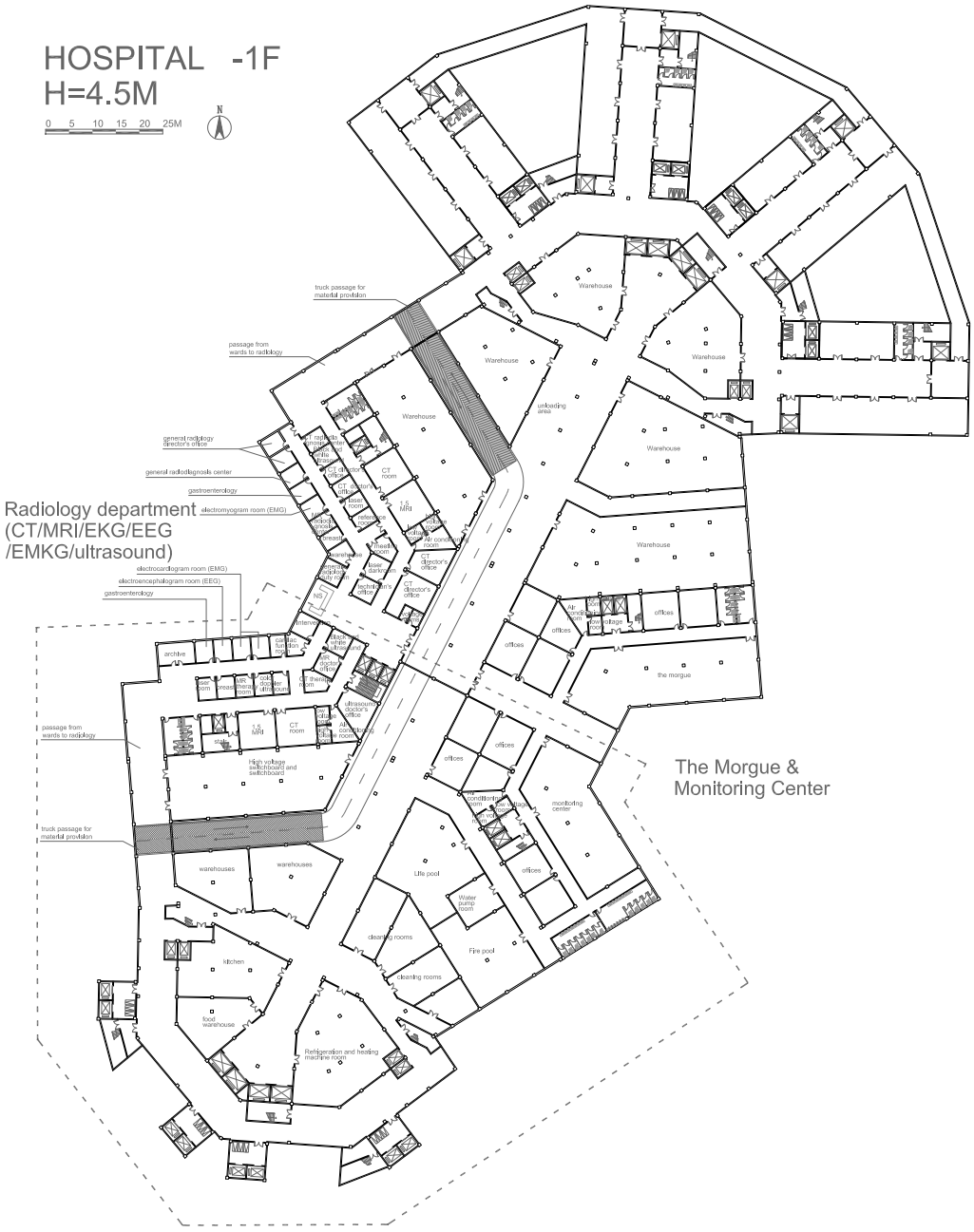


Masterplan of Hospital in pandemic situation

6.5.2 Underground floor

The underground floor is a whole connected together. We cut the whole underground floor in half. The upper part is the general hospital for normal use, and the lower part is the place for the use of infectious disease patients. The middle is separated by a wall and a door.

The hospital changes are framed with dotted lines.



Underground floor of Hospital in pandemic situation

6.5.3 Ground floor

In the pink box are the parts of the renovated hospital, Emergency Department (in A part), D part and 4 ward units which connected to the D part. Other hospital areas not marked in the pink box are normally used.

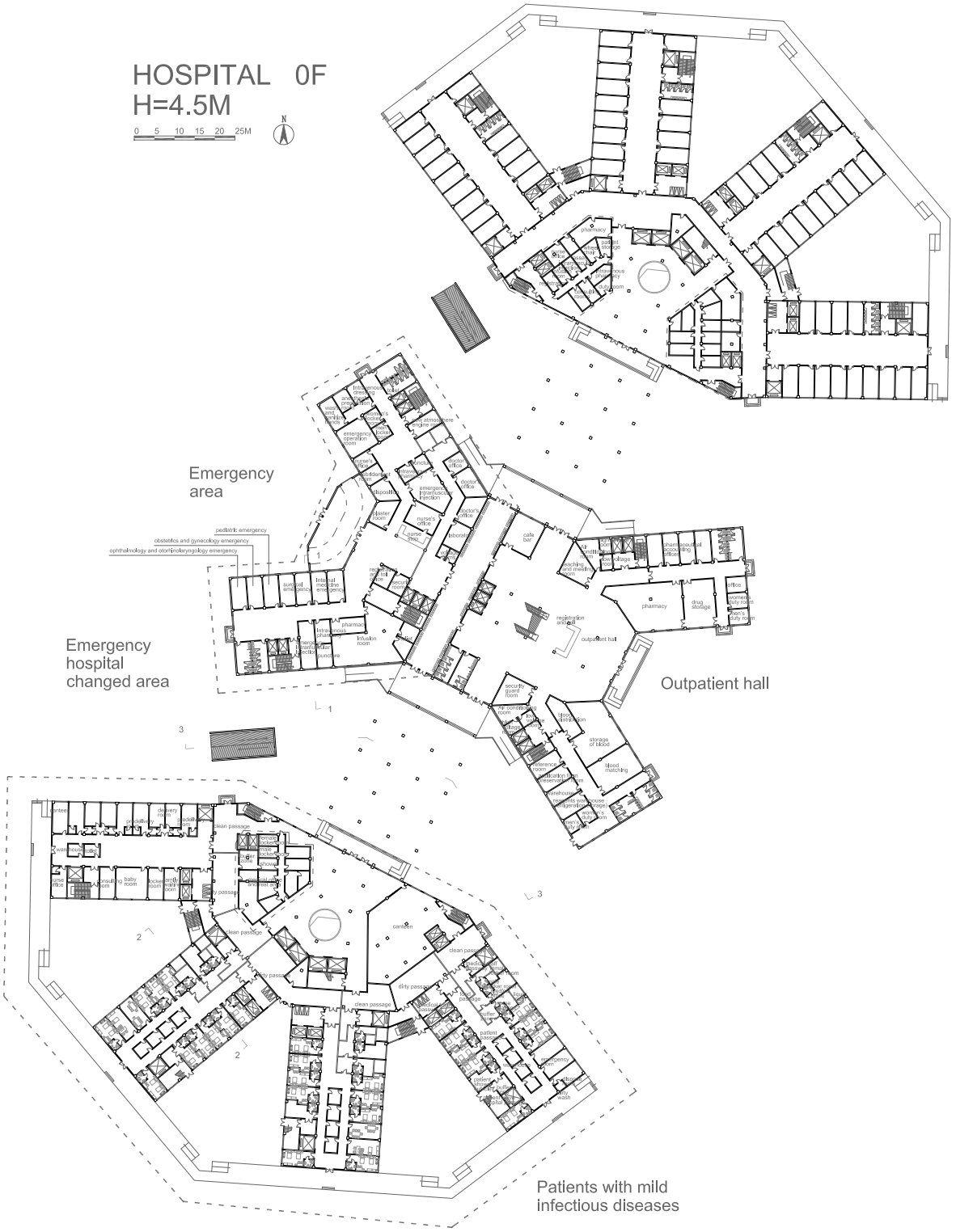
The channel connecting D space and four Ward units was divided into six parts. Clean passage connected ward and the hall, dirty passage connected medical trash passage and outside inside the ward, and transported the medical trash outside the hospital to be destroyed. After the reconstruction, D space has 7 entrances and exits: two staff entrances, one for medical staff and visiting family members, and four medical waste exits. After taking a bath and changing clothes from the ward and coming out through the clean passage, the medical staff can leave the hospital through three D space exits, or continue to work or rest in the medical office and rest area (formerly the Outpatient Department). D space has a total of 8 elevators and 3 staircases, among which the four elevators and 1 staircase in the middle can be used by medical staff and visiting family members, and the two staircases and 4 elevators at both ends can be used by medical staff.

Patients with infectious diseases in the emergency department can go upstairs through the elevator of the emergency department and go to each ward after treatment. Patients with serious diseases can go to the ICU emergency area on the first floor or be pushed to the operating room for surgery. When the condition is stable, it can be pushed into the ward.

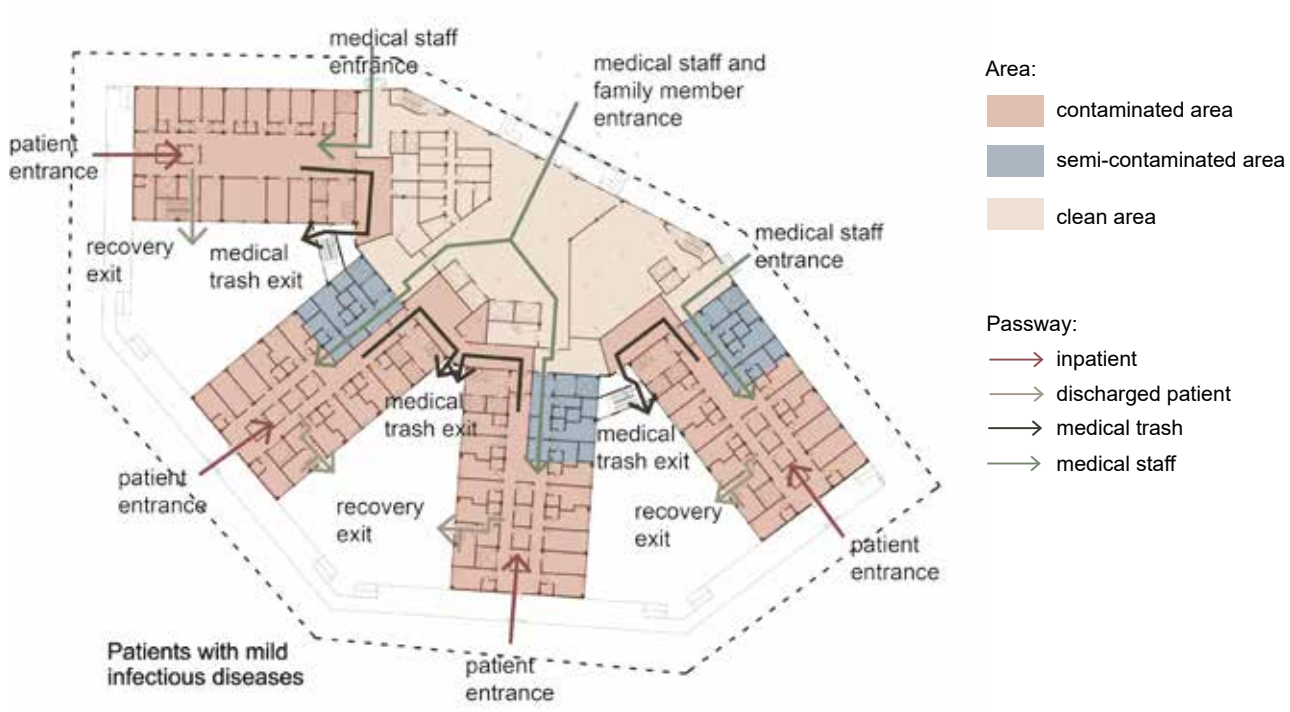
The uncontaminated areas in red are those where patients with infectious diseases stay. Health care workers should pay special attention to whether their skills and equipment are complete to avoid infection. The yellow area is the semi-polluted area, that is, the place where the medical staff work, and the place where they take a bath and change protective clothing. There are no infectious disease patients, but because the protective clothing they take off has virus, they need to take it off in time and clean themselves, and then reach the clean area through the buffer zone. The blue area is the buffer zone, which is the buffer zone connecting different levels of pollution.The green area is the clean area, which allows people to walk freely without wearing protective clothing.

The Emergency Department and Outpatient Hall are separated by walls and doors. During the outbreak, the middle gate will be closed, and the two outpatient entrance in the middle will also be closed because it is too close to the infected area. Medical staff in the Emergency Department will enter through the staff entrance in the middle of AB space, while patients with infectious diseases will be pulled directly to the Emergency Department through the ambulance and enter through the west gate. Ambulances transporting patients with infectious diseases take a special route to the emergency department. During the epidemic, the hospital's emergency department is used to treat patients with infectious diseases.

The wards at ground floor live patients with mild infectious disease, because almost patients are mild, and thier distance of arriving at operating rooms and ICU ward are far relative to the wards at first and second floor.



Ground floor of Hospital in pandemic situation



Clean level and streamlines in ground floor D part

6.5.4 First floor

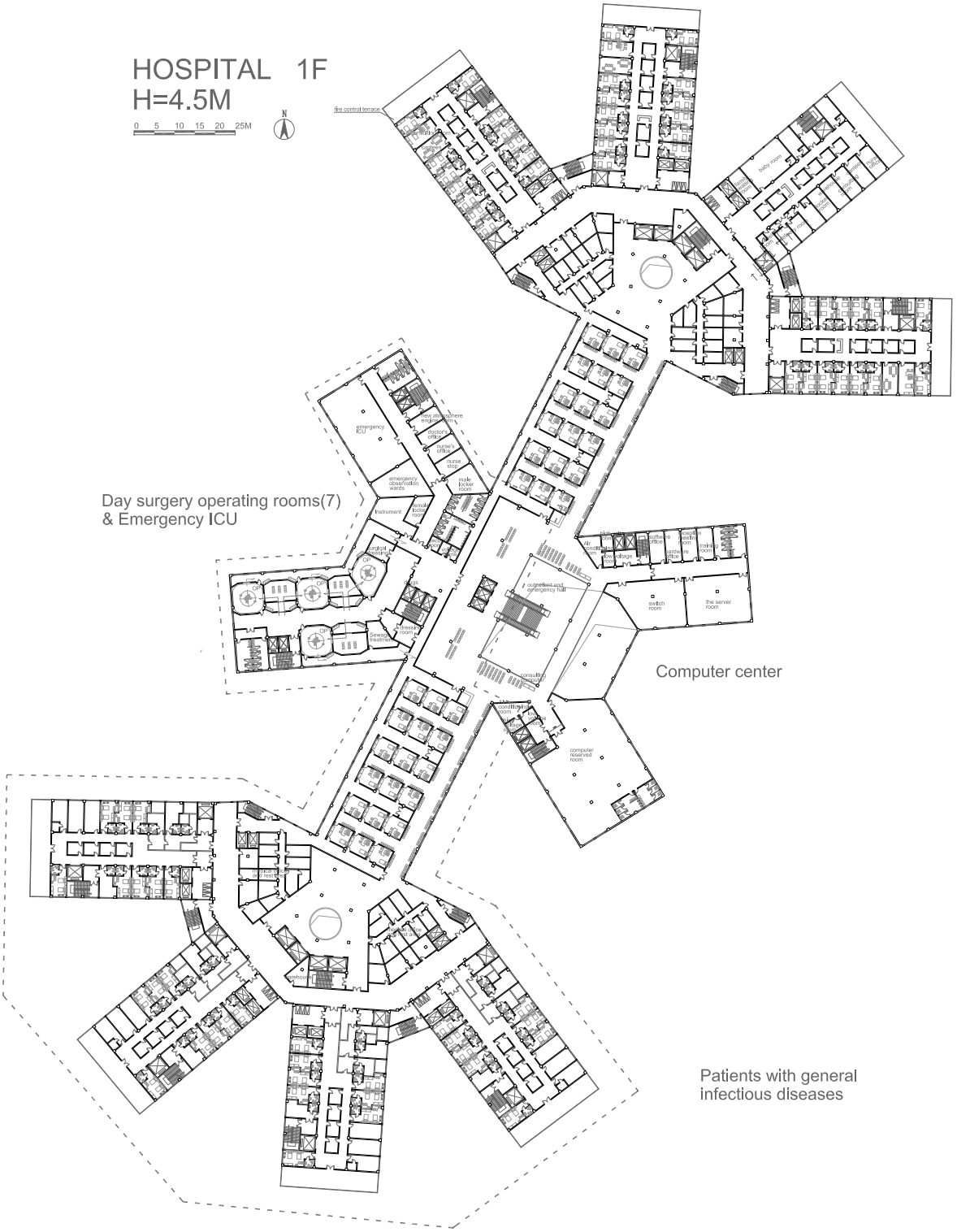
In the First floor, the lower half (including the bridge) and the Day Surgery Operating Room&Emergency ICU are the areas for the treatment of infectious diseases. Only walls and doors were added to the Emergency ICU area and Bridge area on this floor, and the rest of the layout remained unchanged.

The passage between the Day Surgery Operating Rooms and the Emergency ICU connects the rest of the hospital, and this passage is also a semi-polluted area: the operating room is in the south, which is all polluted area;In the north is the Emergency ICU, which includes the area where the medical staff of the Emergency ICU change clothes and enter the Emergency ICU, including the buffer zone and the semi-polluted area. Patients with infectious diseases who have undergone surgery or are transferred from the ICU to the ward enter the D space through the connecting corridor on the bridge and then into the ward area.

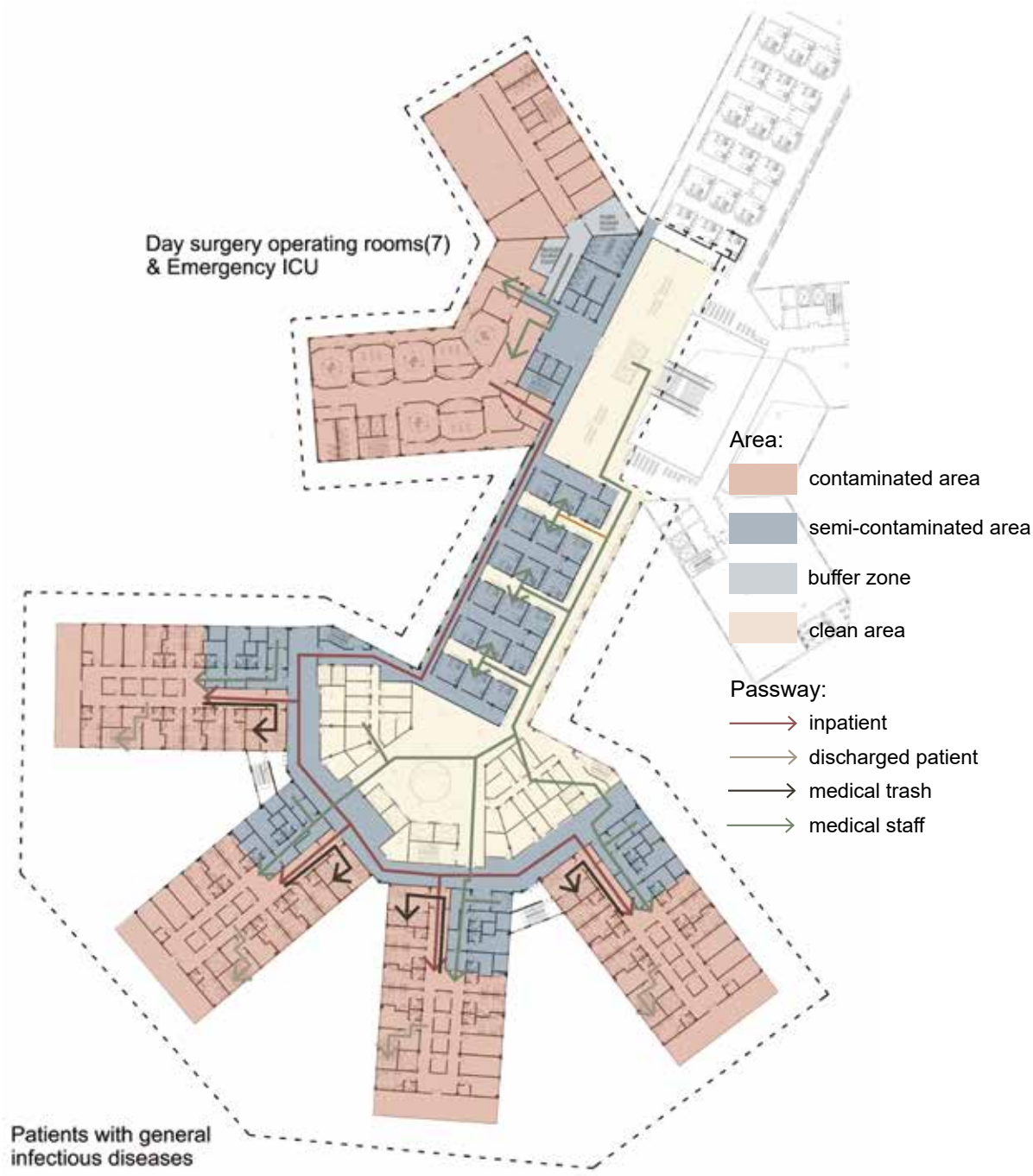
In addition to the passage connecting the hospital ward and operating room, the other spaces on the bridge were originally consulting rooms, which are now used as preparation areas for medical staff, including changing rooms, warehouse and bathing areas. These rooms are separated from the contaminated area by a natural wall with the western corridor.

D space is no longer on the groundfloor all the clean area, most of the regional area for pollution because of the operating room and ICU patients with infectious diseases through D space into the ward, in the ward, f, g, h clean medical staff from the room in the clean area of the elevator down to the hospital, ward e can be directly to D in the space of the clean area to go to work or rest, or to other floors of the east end of elevators and corridor.

The wards at first floor live patients with general infectious disease.



First floor of Hospital in pandemic situation



Clean level and streamlines in first floor bridge, A,D part and ward

6.5.5 Second floor

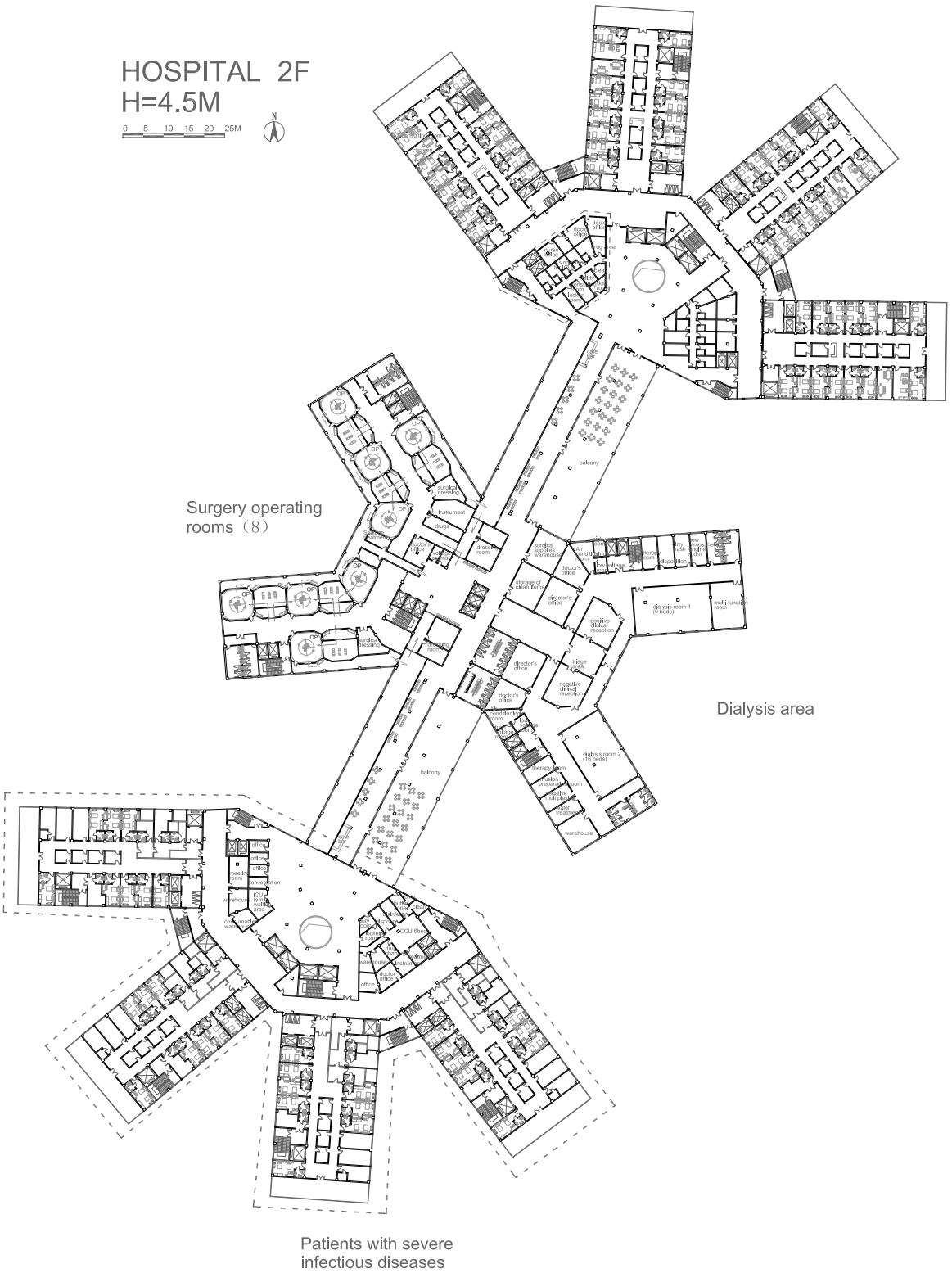
On the second floor, only D space and connected 4 ward units in the south have been transformed into areas for infectious diseases.

In addition to the ICU, D space is a clean area for the activities of medical staff and visiting family members.The staff in the ward tidy themselves up and descend from the lift to Groundfloor for a meal or leave the hospital.Admission to the ICU requires passing through a buffer zone, one for visiting family members and the other for medical staff to walk through.You can go into the ICU after you change your clothes.

The two ward units on the second floor are for patients with severe infectious diseases. Because they are away from the ICU and on the top floor of the whole southern hospital,

the environment is very quiet and conducive to recuperation.

The surgery operating rooms and dialysis area are clean area for non infectious patients.



Second floor of Hospital in pandemic situation

6.6 The design strategy of modified areas in Trofarello hospital

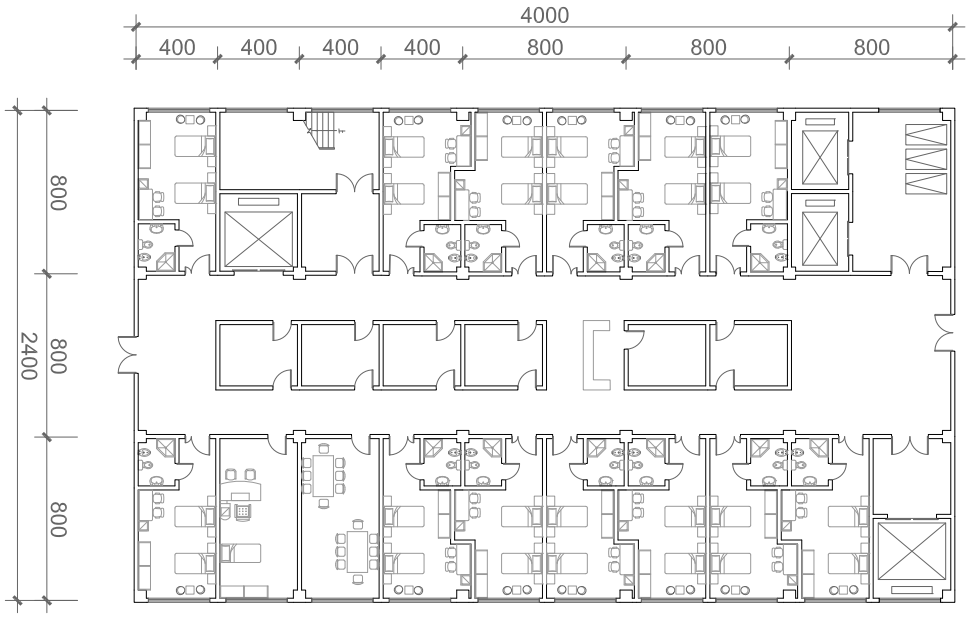
6.6.1 Emergency department

Patients in the emergency department enter through the west gate, and ambulances go through the emergency passage of the original hospital. Medical staff enter the emergency department through the two staff entrance opened by the original hospital in the middle of AB space. First, they go through the clean area, where there is the doctor's office, and at the end of the office there are men's and women's changing rooms. After changing their clothes, they go out through another door of the changing room to reach the buffer zone, and finally enter the polluted area with infectious disease patients.The functions and layout of the emergency department have hardly been changed. The red font is the layout after the transformation and the new functions given by it.

Another option that can be adorpted is to split the emergensy department in two parts for inspectious and non infectious patients provisions a pre-triast on the outdoor areas.

6.6.2 Ward area

Through comparing to ordinary ward and infectious disease ward, can clearly see that we change to place: we removed the near the hospital medical staff in the middle of the working area, the other half of the workspace is a warehouse, and remove the part to not used to protect medical staff infected areas, the pollution area step by step into a clean area. We also changed the functionality of some of the rooms and added a few doors to ease the flow of people.



general ward unit

infectious ward unit layout, function and streamlines analysis

The comparison between the general ward and the infectious ward

During the transformation of the ward, we focused on the circulation of medical staff and infectious disease patients, and based on this, we changed the layout and functional zoning of the ward.

The flow line of infectious disease patients: infectious disease patients enter from the ward door outside the hospital. Patients in the ward on the groundfloor can directly reach their own wards. Other floors can be reached from the nearest elevator (specially for infectious disease patients) outside the hospital. When the patient is allowed to leave the hospital after treatment, he/she first takes a bath and changes from patient shower cubicle. After completion, he/she enters the buffer zone through another door of the room and then enters the stairwell through another door of the buffer zone. This stairwell is specially prepared for the recovered person leaving the hospital.

Streamline of medical staff: Medical staff enter the ward from inside the hospital. There are two doors near the end of the hospital: one is for the passage of medical staff, and the other is medical trash passway. According to the analysis of the groundfloor in the previous section, medical trash passway is a special channel connecting the ward and the outside to transport dirt. From medical staff and medical staff's exclusive channel into the ward, is responsible for the delivery of food staff from delivery window to transfer food to ward, and preparation for entry into the ward staff after the first door into the buffer zone, after going to the locker room first wear protective clothing and other protective equipment, now from the clean area in half pollution area, medical workers after wrap theirselves,go through the door into the second buffer zone, then they can enter the office or directly into the wards, namely pollution area.

In addition to the functional rooms in the semi-polluted area and clean area, there are 8 infectious wards, nurse station with a liquor room, two emergency rooms to rescue patients, and a dispose room with dirty wash.

6.6.3 Natures of emergency hospital must be confirmed and design strategy conclusion

The transformation into an emergency hospital usually has the following characteristics. We will gradually analyze our design methods and strategies according to the classification of routes, convertibility, compartment and outdoor spaces.

Routes
1.decontamination areas for staff
There are special decontamination areas for medical staff in the rest area and in each ward unit, and the consulting room on the bridge in first floor has been changed into locker room, buffer zone and decontamination area.
Patients are basically in the ward, so the ward is the highest pollution area. Medical staff must clean themselves before leaving the ward and arriving at the clean area. The lounge area also has a place to wash itself out. The decontamination area on the bridge is prepared for entering the operating room or going to the clean area.

2.separate / separable paths
The whole transformed hospital is divided into containmated area, semi-containmated area, buffer zone and clean area according to the cleanness level. To go from containmated

area to clean area, you must go through the semi-containmated area or buffer zone. All the passways are classified as inpatient, facilities for treatment of patients, medical staff and medical trash passway according to different population groups, so as to ensure the safety of the uninfected people to the greatest extent.

3.possibility of creating new direct accesses from the outside
After the transformation, the original main entrance and staff entrance have all been changed into the medical staff entrance and exit, while the entrance of the ward is the patient entrance. In addition, a door has been opened in the stairwell of the ward to discharge the recovered patients. Four new doors were opened in D Part to transport the medical trash generated from the ward. These new doors are connected to the Medical Trash Passway of the ward.

4.direct horizontal paths between areas
The ward has three doors, two connecting the ward unit and the D part, and one door connecting the outside, which is used for the admission of patients with infectious diseases. Two doors connect the room. One is connected to the clean area, which is for the access of medical staff and visiting family members. The other is used to transport medical trash, which connects the ward and the outdoor area. In Part D, the corridor that originally connected the ward is divided into dirty passage and clean passage according to the function of the door of the ward unit. Dirty passage is connected to the medical trash generated in the ward outside, and clean passage is connected to the D part and the clean area in the ward.

5.separate entrances and triage for infectious and non-infectious
Because the hospital itself can be intuitively divided into four blocks, located in the east, west, south and north, and connected by corridors in the middle, it can be easily separated into different functions without affecting each other. Four new doors have been opened in D Part to transport medical trash from the wards to the outdoors. The other four doors, which were already there, have been changed to be used only by medical staff, and two of the main doors allow family members to come and go. Only the south 3 floors and the west 2 floors of the whole hospital have been transformed, and the rest are normal use of the general hospital.

6.separate links between different degrees of care intensity (Ter. Ord. - Ter. Intensive covid and non)
The groundfloor in the south of the hospital is the ward for patients with mild infectious diseases. As the most patients with mild diseases get better quickly and the patients have high mobility, it is easy to arrange them on the groundfloor, so as not to disturb the common and severe patients on other floors. First floor is a general infectious disease patient, directly connected to the operating room; Secondfloor is the ward for patients with severe illness, because it has supporting facilities of ICU and is located on the top floor of the south building. The streamline is not easy to be disturbed and the environment is quiet and comfortable, which is convenient for patients to recuperate.

7.controllability of entrance
The medical staff entrance and exit, medical staff and family members entrance and exit, patient entrance, patient exit and medical trash exit mentioned above are all for specific groups of people. Medical staff, medical staff and famiy members, patient, total patient and medical staff, all others cannot pass through.

8.work areas separated by personnel assistance areas
The work area of medical staff is mainly concentrated in the wards, while the assistance areas are in D Part and the bridge, separated from the wards.

Convertibility
1.logistic flexibility
Medical trash of first floor and second floor is transported to the ground floor by the elevator in the ward. After being transported out of the specific exit, it is directly sent to the garbage disposal station. Then, it is transported out of the hospital to the designated place for destruction by truck.

2.single rooms
Single room will be arranged for patients with special requirements or conditions.

3.rooms adaptable to infectious rooms (with filter)
The infectious rooms were transferred directly from the general ward to the infectious rooms, and the machines were installed.

4.flexible signs
Due to the many functions of the hospital, each channel serves for specific personnel, so every fork or gate will indicate the location to which the channel leads, and indicate the applicable population. Each sign is nailed to the wall with a simple material that can be easily removed and replaced.

5.high care spaces adaptablity
The high care space is located on second floor, because the ICU of the hospital itself is located on second floor, with complete facilities, and the top floor is not easily disturbed by other things.

6.separation between clean and contaminated areas
As mentioned earlier, the reformed hospital was divided into four areas according to cleanliness level, the cleanest one being clean area and the most susceptible one being contaminated area. Between the two must cross semi-contaminated area or buffer zone.

7.possibility of switching from positive to negative pressure
Since the transformed hospital accepts infectious disease patients, the operating room needs to realize the conversion of positive pressure and negative pressure. The positive pressure operating room is used for general hospitals, while the negative pressure operating room is used for operating on infectious disease patients.

8.satellite buildings and sectionable autonomous internal nuclei
At the beginning of the design, we had the idea of transforming the hospital, so that when a major epidemic comes, part of the general hospital can be quickly transformed into a hospital for special patients, and the common patients and infectious patients can coexist. So we consciously designed a modular hospital. The four modules are connected by corridors and walls, but they can be easily separated, which is conducive to isolation after the transformation into an infectious disease hospital.

9.space for telemedicine

Trofarello hospital is a smart hospital, which will be equipped with many artificial intelligence and smart medical equipment, including medical-assisted robots and facilities needed for telemedicine.

Compartment

1.compartmentalization of diagnostics / intervention

In each ward unit there is a disposal room for diagnosis of medical records and simple treatment, and two emergency rooms for emergency patients. The emergency room is equipped with the same equipment as the emergency department and is located in the ward unit so that the most rapid treatment can be given to the terminally ill.

2.compartmentalization of sterilization

Infectious disease hospitals should strictly follow the relevant system of isolation and disinfection. For example, medical staff should dress neatly at work and take off their working clothes when eating after work. Wash hands after diagnosis and treatment, dressing change and disposal, and use sterile vacuoles when necessary. Articles should be disinfected and sterilized regularly, disinfectant should be replaced regularly, and the thermometer should be soaked with disinfectant after use; The ward should be regularly ventilated, air disinfection every day, mop and wash the floor, wet wipe the bedside table and chairs every day, cloth should be dedicated, regular disinfection; All kinds of medical appliances must be disinfected after use, medicine cups, tableware must be disinfected before use, patients' bedding must be replaced regularly, such as disinfection.

3.compartmentalization of waste disposal

The garbage generated by the general hospital is transported to the south garbage station for disposal as usual. The garbage from the infectious disease ward is transported outdoors through medical trash passage and directly disposed of in the infectious disease garbage station close to the ward.

4.compartmentalization of the morgue

Patients who have died from infectious diseases may have carried infectious diseases and are also quarantined. We allotted half of the morgues in the general hospital to the infectious disease hospital.

5.buffer spaces between wards

Each ward unit has two buffer zones, one for the medical staff to enter the ward from the outside, and the other for the recovered patients to clean themselves after they leave the hospital. To exit from each ward unit, you must go through the buffer zone.

Outdoor spaces

1.spaces for new volumes

In the masterplan of the new infectious disease hospital, we added a tent for the ward (when the indoor ward is not enough), a garbage disposal station for the infectious disease ward and a tent for ambulance cleaning.

2.areas to be converted (car parks, gyms, meeting rooms, etc.)

The area we converted was car parking and a new tent and garbage house on the lawn to the south.

3.areas for ambulances/outdoor areas for the decontamination of ambulances

Ambulance parking areas are divided into north and south sides, both located next to the entrance to the emergency department. After the reconstruction, the hospital for infectious diseases is located in the south, while the north side is still open to ordinary patients. Therefore, the north side is not changed, and the south side becomes the parking lot for ambulances transporting infectious diseases patients. Four tents have also been set up in the parking lot to disinfect ambulances during the day.

4.health hotel for staff
At the east end of the site, there is a hotel, which can not only open to the public, but also provide a place for staff to live and rest.

5.outdoor areas for possible triage (tents)/availability of outdoor spaces for extensions
At the far south of the hospital there is a lawn with enough space for tents to be set up for infectious disease patients when there are not enough rooms inside. Tents are lined along the road and can be added at any time.

Conclusion

The hospital is a public building design with very strict requirements. It is a huge challenge to design a truly complete hospital layout that can respond calmly to emergency situations, manage partitions, and maintain normal medical order. In addition to the operation of the hospital under normal circumstances, it is also necessary to consider the streamline change of doctors and patients caused by the change of functions in pandemic situations.

This time the author also analyzed the Leishenshan Hospital that was successfully established in Wuhan, China, to ease the epidemic pressure based on the COVID-19 global pandemic. So we began to consider and give some first suggestions on how to design a general hospital that can easily change some functions during the pandemic, while meeting the medical needs of ordinary patients, while opening up a quarantine area for patients with infectious diseases.

The architectural design of a hospital is a very complicated and complex process. Similarly, the detailed design of hospital buildings is a time-consuming and labor-intensive project. A very famous British architect once said that hospital design is equivalent to design in a small city. As an architect, we must have a macro grasp of the layout of the hospital's buildings. At the same time, the architect should also learn as much as possible about the functions and connections of the various departments of the hospital, and meet these requirements through their own design to ensure the best construction plan designed . After many considerations, the author concluded that modular design and hospital transition methods help Trofarello hospital responds to the pandemic.

The following are the important points of modular design for hospital transformation during the epidemic:

1.A variety of modular forms, after analyzing the connection between different modules, optimize and adjust different modules to determine the best building layout distribution to meet The needs of the hospital at present and during the epidemic.

2.The modular design of the hospital summarizes the differences between different elements, optimizes the design plan, removes redundant construction links, on the one hand, saves a lot of manpower and material resources, on the other hand, shortens the reconstruction and construction period during the epidemic.

3.The modularization of hospitals can be constructed in phases, which is conducive to sustainable development and unified function conversion for special circumstances, which can achieve effective control of the overall scale of the hospital, meet the actual needs of the hospital during the epidemic, and improve the medical performance of the hospital.

On the other hand, the emergency renovation plan of the Trofarello Hospital during the epidemic is also extremely important. It is based on the building layout designed based on ordinary conditions, and the design is carried out according to local conditions, and the layout is basically reasonable. The transformation plan focuses on the following points:

1. Outdoor space: new volume space; reconstruction of parking lot, fitness area,

entertainment area and other areas as temporary wards; requisition of part of the blank land as a dedicated ambulance area for infected patients; staff hotel temporarily as an isolation ward doctor’s dormitory; temporary construction tents to increase possible outdoor triage areas; other outdoor spaces for expansion.

2.Route: set up decontamination area for staff; separable path; possibility of creating new direct access from outside; direct horizontal path between areas; isolated entrance and non-infectious triage; infectious disease patients and ordinary patients Different levels of care intensity; controllable entrance; work area separated by staff assistance area.

3.Convertibility: flexibility/redundancy of engineering factories; flexibility of logistics; switching between single rooms and double rooms; rooms with filters suitable for infectious rooms; possibility of switching from positive pressure to negative pressure Signs of flexibility; high adaptability of nursing space; separation of clean area and pollution area; re-functionalization of lung cavity; satellite building and internal core that can be segmented and autonomous; telemedicine space; IoT tools.

4.Compartment: the division of diagnosis/intervention; the division of sterilization area; the classification of waste disposal; the division of morgue; the buffer zone of the ward; the space for the maintenance of engineering equipment.

The author hopes that the above two aspects summarized in the process of the architectural design and renovation of the Trofarello Hospital can enhance the hospital builders' simple understanding of the hospital's modular design and its transition to respond to the pandemic. At the same time, it is hoped that it can make some contributions to the practical construction work of transforming general hospitals into isolation hospitals during the pandemic.

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