Design Strategies for Infectious Disease Departments in General Hospitals under the Dual Consideration of Normal-pandemic Situation: Basing on the Case of Shenzhen in China

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1 Background and Purpose

Since 2019, COVID-19 has been raging around the world and has had a significant impact on the healthcare system, promoting the reforming and updating of infectious disease departments in general hospitals. In China's major epidemic prevention and treatment network (see Fig. 1) [1], infectious disease departments in general hospitals occupy an important position and assume the task of screening suspected patients and treating patients. However, since the SARS epidemic and the implementation of the construction of infectious disease departments in general hospitals in China, most infectious disease departments have been operating under the condition of non-epidemic conditions for a long time. Therefore, the development of infectious disease departments has not been sufficient. Therefore, in this epidemic, infectious disease departments exposed the problems of insufficient construction quantity, insufficient building space and equipment, and insufficient management system. Based on historical development lessons, dual consideration of normal-pandemic situation has become an important goal for the new renewal and improvement of the infectious disease departments.Existing research on infectious disease departments under the dual consideration of normal-pandemic situation mainly focuses on the emergency reconstruction or construction of related medical facilities in response to the epidemic [2, 3]. With the gradual arrival of the post-epidemic era, how to use the emergency facilities and how infectious disease departments deal with the next epidemic needs more systematic, in-depth and long-term thinking.

In view of the challenges faced by infectious disease departments in general hospitals after COVID-19, this paper adopts the method of combining theoretical research with practical research. Based on epidemiology and infection control infection, infection of architecture of interdisciplinary research in-depth analysis flat plague difference of architectural design, based on general hospital personnel semi-structured interview in Shenzhen to extract the influence factors of disease combined with, puts forward design strategies for infectious disease departments in general hospital, for the infection of the flat disease combined with the design to provide theoretical basis and design inspiration.

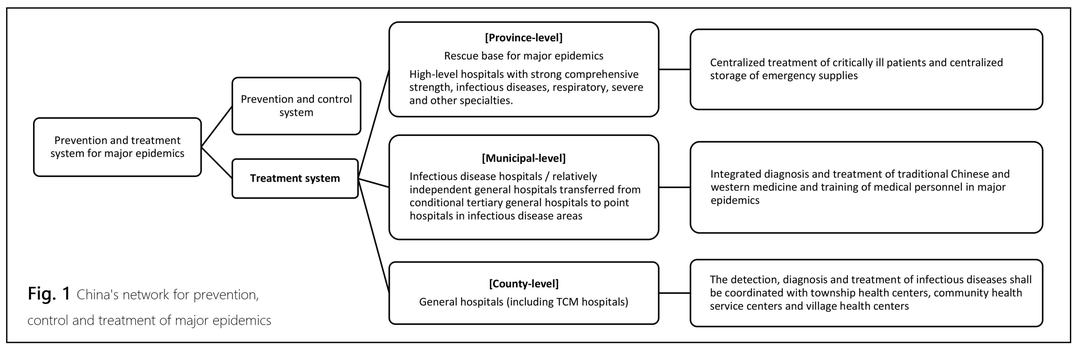

Fig. 1 China's network for prevention, control and treatment of major epidemics

2 The difference between normal and epidemic conditions

2.1 Differences in diseases coping with

Generally speaking, infectious diseases can be divided into two categories: the first category is infectious diseases that are highly infectious and may cause epidemics or even worldwide pandemics; The second category is infectious diseases constrained by climate, geography and other conditions, which can only cause partial, local or seasonal epidemics [4]. In the non-epidemic state, infectious disease departments mainly deal with the second type of infectious diseases (see Fig. 2), which are characterized by low infectivity, stable and controllable. In the epidemic state, we should mainly deal with the first type of infectious diseases, such as SARS and COVID-19, which are often highly infectious emerging infectious diseases, characterized by 1) uncertainty, 2) suddenness, 3) unknown, 4) strong infectivity.

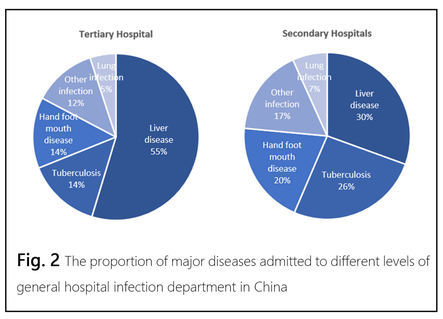

Fig. 2 The proportion of major diseases admitted to different levels of general hospital infection department in China

2.2 Differences in the need for prevention and treatment

Infectious disease departments need two capacities to deal with infectious diseases.

1) The ability to screen and treat infected patients needs the support of manpower, goods and space resources. Under the epidemic situation, due to the exponential increase in the number of patients, the demand for medical personnel, medical supplies, and space capacity of the infection department will greatly increase.

2) The ability to prevent and control infectious diseases requires the management of patients, medical care and materials. In the state of epidemic, suspected patients with infectious diseases should not only be absolutely separated from ordinary patients, but also be kept in close isolation during observation and treatment. In addition to the basic protection under non-epidemic conditions, medical staff also need to wear protective clothing, isolation clothing, shoe covers and other additional protection. The delivery of clean materials and the classification and disinfection of contaminated materials also have more detailed requirements.

2.3 Differences in the design content of Infectious Disease Departments

2.3.1 Flow organization

1) Patient streamline. Patients in non-epidemic condition were triaged through the outpatient hall, then examined and treated (see Fig. 3). In the case of the epidemic, patients need to undergo pre-examination, confirmed patients are sent to designated hospitals for treatment, and suspected patients are further screened (see Fig. 4).

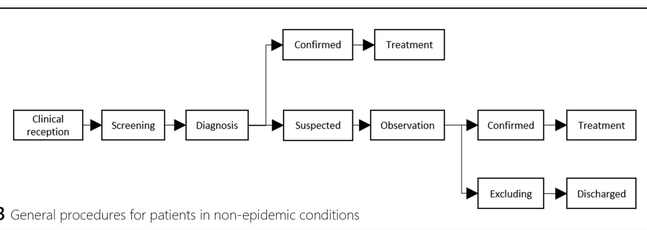

Fig. 3 General procedures for patients in non-epidemic conditions

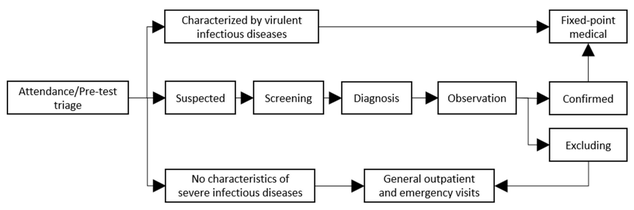

Fig. 4 Patient consultation process under pretest and triage during epidemic

2) Medical streamline. In non-epidemic conditions, the process of wearing and removing protective equipment for medical care is simple, often requiring only a buffer room (see Fig. 5). In the state of epidemic, more buffer space is needed for medical care to wear and take off protective equipment according to the level of risk, so as to meet the isolation in the process of wearing and taking off protective equipment [5]. (see Fig. 6).

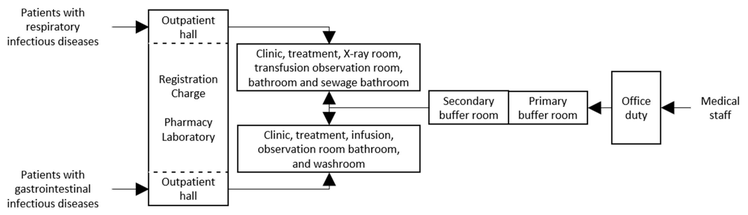

Fig. 5 Medical care streamline under non-epidemic condition

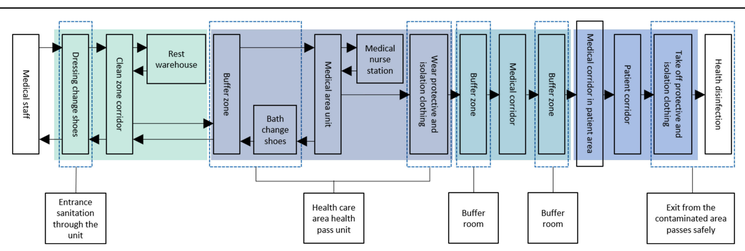

Fig. 6 Medical care streamline under epidemic condition

3) Material flow line. In an epidemic situation, supplies need to be transferred through a transfer window or a transfer room to avoid damage to the isolation environment of infectious disease departments.

2.3.2 Function configuration

Outbreak conditions, in addition to the locker room, the buffer room, clinic, waiting room, registration fees, pharmacy, clinic, isolation of observation, blood collection room and checkout room, the basic function of the epidemic situation, also need to preview station, negative pressure isolation ward, wear protective gear off the dressing room, disinfection room, respiratory tract sampling room, etc. There will also need to be more clinics and isolation wards, as well as larger waiting rooms.

2.3.3 Functional layout

The functional layout of infectious disease departments is mainly in the mode of "three areas and two channels", that is, the clean area, the semi-polluted area, the polluted area, and the medical and patient channels. The difference between normal times and epidemic times mainly lies in that in normal times, more attention is paid to the separation between clean areas and semi-polluted areas, while in epidemic times, more attention is paid to the separation between semi-polluted areas and polluted areas because of the higher risk of semi-polluted areas. When necessary, semi-polluted areas and polluted areas are treated equally.

2.3.4 Space environment

In the non-epidemic state, natural ventilation and lighting can well kill the bacteria in the environment. In the epidemic situation, it is often necessary to adopt mechanical ventilation to shape gradient negative pressure environment.

3 Influencing factors

This paper conducted semi-structured interviews with architectural designers (n=4), hospital administrators (n=3) and front-line medical workers (n=3) of relevant hospitals in Shenzhen.
In combination with the differences of epidemic prevention in infectious disease departments in general hospitals, the interview outline was constructed from four aspects: the problems faced by the infective department, the strategies to solve the problems, the situation to solve the problems, and the thinking on the development of epidemic prevention and treatment.
After the interview content is transcribed, the content of this paper is continuously analyzed, and the open coding and spindle coding are carried out. Finally, 11 sub-categories and 54 sub-categories are obtained. The specific results are shown in Table 1.

Table 1 Open coding and spindle coding results

Spindle coding - Sub-category		Open coding - Subcategories (Reference points)
Problems	Insufficient resources	Insufficient construction area (10), Insufficient allocation of construction equipment (12), Insufficient medical equipment (21), Insufficient medical personnel (16), Insufficient medical supplies (9)
	Poor management	Patient management (3), Health care awareness (7), Health care prevention and control skills (2), Material management (2)
	Reasons	The standard is not strict (22), Less patients are admitted (18), The examination is not strict (11), Insufficient funds (8), Infectious disease hospitals occupy the main patients (4).
Influencing factors	Positioning function	Epidemic prevention and control system planning (36), Construction objectives (31), Patient admission rate (15), Scale and number of hospital beds of the infectious disease department (22), Service business (29)
	Campus planning	Surrounding environment (41), Site conditions (33)
	The budget of the economy	Operation and development mode (34) Government support (24)
	Epidemic prevention standards	Expert opinion (51), Hospital idea (18), National standard (78), Local standard (5)
Design strategies	Design features	Flexibility (7), Adapting measures to local conditions (16)
	Design approach	Expansion (22), Reconstruction (15)
	Design objects	Fever clinic (82), General infectious disease clinic (39), Infected ward (56)
	Design elements and key points	Streamline organization: Streamline separation of patients (44), Reducing the frequency of medical care changing protective equipment (9), Reducing the traffic area of medical passage (9)
		Function layout: Layout of three areas and two channels (75), Transformation mode of common ward (12)
		Functional configuration: Buffer room (9), Wearing and taking off protective clothing (16), Number of isolation beds (13), Consulting room (11), Outpost station (16), Medical technology examination function (34), Auxiliary space (7), Medical care space (22), Multi-function (7)
		The space environment: Mechanical ventilation (24), Natural ventilation (13), Double system parallel (6)
		The expansion of the location: Independent area (39), Protection distance (12)

3.1 Functional positioning

Functional positioning is the most critical factor affecting the combination of infectious diseases and epidemics, which determines the differences in the design content. To deal with the epidemic, China has set up an urban infectious disease prevention and treatment network that combines epidemic prevention and treatment with hierarchical classification and efficient coordination. According to the location of the general hospital in the network, the usual number of patients admitted to infectious diseases and the development level of the infection department, the regional health system determines the responsibilities of the general hospital in peacetime and epidemic time, so as to determine the task and scale of its work.

3.2 Economic budget

Economic budget determines the level and way of construction of the combination of infectious diseases and epidemics. In the non-epidemic situation, infectious disease departments are not profitable for a long time, which leads to the problem of insufficient construction. Therefore, the establishment of infectious disease departments needs the support of the government, which has been greatly improved in the case of COVID-19. At the same time, infectious disease departments need to have a good operation and development mode, which requires infectious disease departments in the design of the epidemic combined with consideration, improve the usual utilization rate.

3.3 Epidemic prevention standards

The design standard of epidemic prevention plays an important role in promoting the safety of the combination of Coping epidemic infection. However, in actual operation, due to the limitations of function positioning, economic budget, hospital district planning and other aspects, as well as the different understandings of the hospital and designers for the standard. Designers need to communicate with the hospital constantly, which is often finally reviewed by experts, so as to determine the plan that is safe in peacetime and epidemic.

3.4 District planning

The planning of the hospital determines the surrounding environment and site conditions of infectious disease departments, and influences the design approach and strategy of the combination of epidemic prevention and treatment. Influencing factors of the surrounding environment of infectious disease departments include the flow of people, the direction of air flow, the entrance and exit of the hospital, the relationship and distance between the hospital and the medical facilities, etc. In the face of different conditions, different strategies should be adopted to control the epidemic. The influencing factors of infection site conditions include scale area, expansion land, building structure, etc., which affect the design approach of the combination of infection and disease.

4 Design Strategies

According to the different ways of coping, the design strategies for dual consideration of normal-pandemic situation can be divided into two types.

1) Epidemic transformation: two modes are used in peacetime and epidemic time, and transformation is carried out in the outbreak of epidemic situation through the design of contingency plan. It is mainly aimed at infectious disease departments that have differences in their functions, and often need to undertake certain responsibilities of screening, testing and treatment when an epidemic occurs. According to the factors of economic budget and district planning, it can be divided into two ways: emergency expansion and space transformation.

2) Coordination between normal and epidemic situation: a mode is adopted for epidemic control and epidemic control, which is mainly aimed at infected families with similar epidemic control functions. The first category is the infectious disease department as the regional infectious disease treatment center, which is less affected by the economic budget and the hospital district planning, and usually adopts the highest epidemic prevention standard for standardized design according to the standard, which will not be discussed in this paper. The other is the infection department, which treats almost no patients and serves only as a basic screening site in peacetime and epidemic times. The economic budget is the core influencing factor of this kind of infection department, so it is necessary to build an economical and suitable way for normal and epidemic situations.

4.1 Normal-pandemic situation of spatial transformation type

1) The versatility of functional housing
The design of various functional rooms considers the needs of multiple uses and should be converted to meet the needs of different periods, which can not only meet the security needs of streamline organization, but also increase the number of configurations.

2) Flexibility of functional layout
At the same time, functional layout can be flexibly transformed according to streamline organization and functional configuration. For example, the general outpatient service and the fever outpatient service adopt similar functional layout, which can be flexibly transformed into the fever outpatient service in the case of epidemic, thus expanding the capacity of the outpatient service space. The standard ward can realize the functional layout of three areas and two channels through the function transformation of the disposal room, storage room and buffer room, and increase the number of beds in the infection ward.

3) Flexibility of the space environment
Equipped with two sets of ventilation systems in epidemic state and non-epidemic state, the space environment can be flexibly transformed in different periods.

4.2 Normal-pandemic situation of emergency expansion type

1) Coordination of flow organization
The expansion facilities should be well connected with the original facilities to maintain the coordination of the flow lines, so as to avoid the repeated entry and exit of medical care in the polluted area and reduce the work efficiency.

2) Reservability of functional configuration
By reserving sites and space and allocating basic equipment, we can expand rapidly in case of epidemic and realize epidemic transformation. For example, the site of emergency medical facilities and basic pipelines are reserved, the site of pre-inspection and screening, and ventilation equipment are reserved.

3) Sustainability of functional configuration.
Mobile facilities or temporary structures, such as medical vehicles and medical tents, can be used to meet the needs of expansion of space capacity during the epidemic, which can be well recycled during the non-epidemic.

Fig. 7 Outdoor waiting area built in emergency

Fig. 8 Emergency pre-test triage table

4.3 Normal-pandemic situation of economical adaptation type

1) High efficiency of flow organization and functional layout
Reduce the traffic area of the medical passage and improve the utilization rate of the area.

2) Simplicity of functional configuration
Equipped with the most basic key functions to meet the screening needs, such as pre-test triage, consulting room, observation room, buffer room, shower room, changing room, material storage.

3) The economy of the space environment
Adopt natural ventilation and lighting to reduce cost. Reduce the risk of the space environment through enhanced management. At the same time, in order to avoid pollution to the surrounding environment, the infectious department of this kind of anti-epidemic combination is to keep a safe and epidemic prevention distance of 20 meters from other buildings.

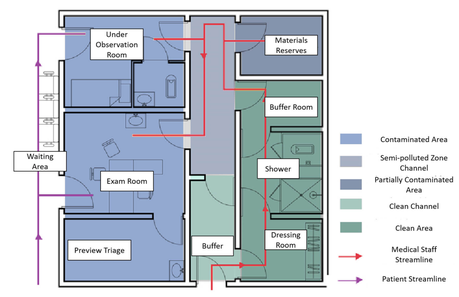

Fig. 9 An example of an economical and applicable scheme for epidemic prevention combined with infection department [6]

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