Research on Epidemic Prevention Design for Coping with Public Health Emergency in the Guangdong-Hong Kong-Macao Greater Bay Area—Taking COVID-19 Epidemic Prevention as an Example

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Abstract. Under the background of the normalized COVID-19 epidemic, the Guangdong-Hong Kong-Macao Greater Bay Area (hereinafter referred to as "Greater Bay Area") needs to improve its ability to cope with public health emergency. In view of this situation, this paper analyzes the regional particularity of the Greater Bay Area and its requirements for public epidemic prevention, puts forward design principles of the public epidemic prevention for the Greater Bay Area to cope with public health emergency, and puts forward the possibility and solution of a design scheme with taking the public epidemic prevention passage as the design case.

Keywords: The Greater Bay Area · Epidemic Prevention Design · COVID-19

1 Introduction

Public health emergency refers to the epidemic of major infectious disease, group unexplained disease, major food and occupational poisoning, and other serious public health events that occur suddenly and may cause serious damage to public health [1]. The effective response to public health emergency (hereinafter referred to as "emergency epidemic") reflects the capabilities of modern governance and containment of a country or region. The Greater Bay Area is located in the land-sea junction zone of southern China. The close exchange and the frequent regional and multinational traffic within the Greater Bay Area result in the particularity and complexity of the public prevention and control of the emergency epidemic [2] . In all emergency epidemics, infectious diseases are classified as the most important category due to their strong suddenness and major health risks. For example, given the global spread of COVID-19 epidemic in 2020, the

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World Health Organization (WHO) has formally defined the outbreak of COVID-19 as Public Health Emergency of International Concern. After the epidemic had been brought under control and stabilized in China, there was still a serious resurgence in Guangzhou and Hong Kong. Epidemic prevention design is to block or reduce the spread of the virus through scientific and convenient products or related services, so as to raise the professional level of regional response to the emergency epidemic and reduce the negative impact of the emergency epidemic on people's livelihood and social development, which plays a vital role in improving the ability of epidemic prevention and control [3].

2 The Particularity of the Public Epidemic Prevention Design in the Greater Bay Area

2.1 Transmission Characteristics of COVID-19

The characteristics of public health emergency include diverse causes, differentiated distribution, wide transmission, complex harmfulness, comprehensive management, diverse types, and constant new emergencies, among which wide transmission and complex harmfulness are especially predominant [4]. The main transmission routes of COVID-19 are respiratory droplet transmission, aerosol transmission, and contact transmission. There is a certain incubation period after the human body is infected, and COVID-19 is highly contagious and concealed in the initial stage of transmission. Therefore, it is much difficult to identify the asymptomatic and carriers, which puts forward higher requirements for rapid virus detection and individual travel tracking.

2.2 Scope of the Public Epidemic Prevention Design

The public epidemic prevention design is for the public. On the one hand, the public epidemic prevention design focuses on the non-infected people and non-virus carriers, the largest group in society, and ensures the necessary production and living activities of the individuals in the social living environment through epidemic prevention products and related services to reduce the adverse impact of emergency epidemics on the economy and life. On the other hand, it pays attention to infected people and carriers, and pays more attention to the effective treatment and humanistic care for them on the basis that they will not infect more people. Therefore, the public epidemic prevention design includes the following contents:

Design of health monitoring facilities and related services. Rapid health detection for the floating population is the key to the prevention and control of the epidemic, which can provide data support for the rapid control of the emergency epidemic and help in cutting off the transmission path and carrying out the prevention and control work as soon as possible. Commonly used health monitoring indicators, such as body temperature, heart rate, blood oxygen, and blood pressure, can be obtained by thermal imaging, optical measurement, and other techniques.

Design of disinfection-related tools. For the emergency epidemic where contact transmission occurred, the contact points of public facilities, such as password input devices of the cash register, buttons of public elevator, seats, and railings, need to be cleaned and disinfected repeatedly to avoid becoming the source of infection [5]. Commonly used disinfection methods include thermal disinfection, chemical disinfectant, and ultraviolet disinfection.

Epidemic prevention design of vehicles. The vehicle is an important means of material and manpower transportation, and it is also highly concerned by the epidemic prevention due to its high mobility and relatively closed space. While the work of individual protection is well performed, attention should also be paid to the ventilation of vehicles, the disinfection of public facilities, and the increase of the space between people.

Medical-related epidemic prevention design. Healthcare workers directly contact infected people or carriers in the treatment of patients, so requirements for medical epidemic prevention and protection are higher. On the one hand, the epidemic prevention design should take into account all aspects of medical behavior, such as transfer equipment for infectious disease patients, wartime hospitals, and mobile treatment chambers and facilities to ensure the life safety of healthcare workers. On the other hand, with the rapid development of information digital technology and artificial intelligence, more products and services that apply or combine new technologies, such as intelligent robots, mobile health, and remote diagnosis services, have been innovated and developed, which facilitates increasing the humanistic care for the treated group and improving the efficiency of treatment.

Extension of service design under the emergency epidemic and related product design. Affected by the COVID-19 epidemic, the delivery industry is severely tested, and the eat-in service especially suffers tremendous losses. The contact-free delivery service adopted by takeaway and express businesses is developing rapidly, and new measures such as the addition of deliveryman health cards and self-service delivery cabinets present new trends.

Design of ecological environment protection under the emergency epidemic. Medical waste contains a large number of pathogenic microorganisms, and the emergency epidemic can cause a sharp increase in medical waste. Therefore, the design should consider the full life cycle of medical products and focus on the disposal of disposable medical products (including the process of collection, delivery, storage, and disposal of medical waste) to avoid the risk of environmental pollution and secondary infection.

2.3 Particularities of the Public Epidemic Prevention Design in the Greater Bay Area

The Greater Bay Area is a large-scale urban agglomeration with the "9 + 2" urban pattern, formed by nine cities of Shenzhen, Guangzhou, Foshan, Zhaoqing, Dongguan, Huizhou, Zhuhai, Zhongshan, and Jiangmen, and two special administrative regions of Hong Kong and Macao [6]. Different from administrative areas, the Greater Bay Area has

its particularity in the aspects of culture, traffic, medical basis, economic development, and the epidemic prevention for emergency epidemic.

1) "One country, two systems, three legal systems, and multiple languages" and multicultural background.
There are two systems among the three regions in the Greater Bay Area. The three regions also differ in legal systems and medical standards, as well as languages (including spoken and written). While the regional joint prevention and control is carried out in the Greater Bay Area, these differences put forward more and higher requirements for the generality of epidemic prevention products and services, identity recognition, and database construction, such as the design of the generality of the identification and sign system and the identity recognition system.

2) Frequent cross-regional interaction, large floating population, and close international exchanges.
The high-density traffic network in the Greater Bay Area grows with the increasing interaction among Guangdong, Hong Kong, and Macao. These regions have gradually become the fully functional, timely and reliable, smoothly exchanged, cost-effective portal and hub that forge ahead in aspects of land, air, and sea and are connected with the Belt and Road Initiative. The highly developed traffic network system facilitates the rapid transportation of materials and the flow of people, and it is also likely to lead to the cross-regional transmission and overseas import of the virus in an emergency epidemic. In addition, the close international exchanges in the Greater Bay Area are used as a platform, and the effective measures for the prevention and control of emergency epidemic are used to demonstrate regional prevention and control capabilities, which help in enhancing the international influence of the Greater Bay Area.

3) Higher level of health infrastructure and information exchange.
With a highly developed economy, the Greater Bay Area has invested heavily in the design and construction of major areas such as medical treatment and public health. Therefore, the area has advantages in material storage, medical informatization, database construction, and remote assistance, and can quickly build information networks and service systems in line with specific epidemic prevention goals. In addition, the Greater Bay Area has a good basis for combining traditional Chinese medicine with western medicine in therapeutics, and people in this area have better learned and accepted the idea of the combination of traditional Chinese medicine and western medicine.

3 Principles of the Public Epidemic Prevention Design

With an eye to epidemic prevention needs and on the basis of scientifically and effectively blocking the spread of the virus, public epidemic prevention design pays more attention to the behavior and psychological state of the public in the process of epidemic prevention and control. The public epidemic prevention design should abide by the following principles:

Principle of effective protection. Public epidemic prevention aims to effectively isolate the human body from the source of infection and block infectious agents such as

viruses and other possible infection factors, so as to avoid the concentrated large-scale spread of the epidemic to the greatest extent. For different emergency epidemics, the protective measures and paths are also different. The epidemic prevention measures and disinfection methods also vary according to different types of epidemics, transmission modes, and characteristics of pathogens. In the face of different severity levels of the epidemic, the public needs different levels of epidemic protection. The relevant public epidemic prevention design should adapt to the use environment.

Principle of safety. The public epidemic prevention design gives priority to the protection of human health and avoids any risk factors brought during the epidemic prevention process. The safety principle is mainly reflected in: ① The method is safe and reliable. On the basis of reasonable form and reliable structure, public epidemic prevention products should also have good operability and effectiveness. For example, the epidemic prevention facilities should clearly indicate the corresponding protection level and functions to facilitate the rapid identification of users; ② The performance is safe and environmentally friendly. In the material selection and use of public epidemic prevention products and chemical disinfectants, special attention should be paid to the material selection of products that have direct contact with the human body, such as skin protective agents, to avoid human body injury and negative emotions; ③ The recycling is safe and effective. In view of the particularity of epidemic prevention products and the situation that some public epidemic prevention products have been contaminated by viruses after use, the recycling and cleaning methods of public epidemic prevention products should be fully considered in the design stage to avoid environmental pollution and secondary infection to the human body caused by product wastes.

Principle of usability. Public epidemic prevention is designed for the public, which requires that products and related services facing different crowds should be easy to use and operate. The usability principle is mainly reflected in: ① The functions of public epidemic prevention products and services can be quickly identified by the public and resonated with them, so users can master the use of products in a short time; ② Reasonable operation methods and use processes ensure the efficiency and fault tolerance, so users can quickly achieve their desired goals. Even if use error occurs, it can be found and corrected in time; ③ Unnecessary functions should be avoided to reduce unnecessary operation obstacles and the cognitive load of users. For example, if pathogen carriers are identified by monitoring and testing products, corresponding space blocking measures should be implemented to quickly separate them from the rest of the public.

Principle of humanistic care. While working on the safety and function of products, public epidemic prevention design should also pay attention to the humanistic care of products and services, so more easy-to-use products and comfortable services will be available for the public. For example, the personalized differences of users at the ergonomic and cognitive levels are valued, and the code scanning and ID card identification are not used in epidemic prevention facilities in kindergartens, schools, and other places. In addition, the epidemic prevention design should take into account the human body size and cognitive ability of children and the elderly, rather than just making size changes in product segmentation, so as to avoid the revulsion of specific groups.

4 Design of the Public Epidemic Prevention Passage

Typical public gathering environments include transportation hubs such as airports, high-speed rail stations, passenger transport stations, and customs clearance ports, as well as schools, hospitals, and commercial centers. Such public places have the characteristics of large flow of people and frequent movement. Especially in the post-COVID-19 era, long-term attention should be paid to the epidemic prevention and control of the entrance and exit environment in residential areas and office spaces. Public epidemic prevention passage is a kind of product that emerged against the background of the COVID-19 epidemic and is placed at the entrance and exit of public gathering places. As a multi-functional and compound typical public epidemic prevention tool, it has a representative design process.

4.1 Analysis of the Current Situation of the Public Epidemic Prevention Passage

In view of the characteristics of the prevention and control of the COVID-19, public epidemic prevention passages are required to be clearly built in public places. A series of epidemic prevention measures are often required to be carried out in actual situations, which can be described as: The staff will check whether the entrants wear masks, measure their body temperature with a handheld thermometer, and then check the health code (including the travel code) on their mobile phone. The staff will sometimes ask the entrants to register their personal and travel information, and then guide them to disinfect their hands. The above range of measures has proceeded in a linear manner. It takes a person 30-60s to complete the whole process, which is very likely to cause congestion and increase the risk of infection. In addition, public epidemic prevention passage often requires 2–3 staff, which undoubtedly increases the probability of infection and additional repetitive work for the staff, as well as additional labor costs.

4.2 Analysis of Design Requirements of the Public Epidemic Prevention Passage

A survey was carried out to investigate the public epidemic prevention requirements of typical public gathering scenarios. Ideally, all functions are expected to be realized within 15s after the entrant enters the passage. The design requirements of the passage can be reflected in both information requirements and functional requirements, and there is a mapping relationship between them, which can be described as: ① Health code scanning: Although the health code systems used in Guangdong, Hong Kong, and Macao are different, they have all realized the technical coverage of "one person, one code". The health code can effectively display the past health information of the entrant, which can avoid the possibility of an epidemic spreading again in high-risk areas. Meanwhile, since entrants are required to operate their mobile devices in this place, they need to be guided and prompted in advance; ② Body temperature measurement: The measurement of the body temperature of current entrant adopts infrared thermal imaging technology that has achieved the accurate temperature measurement within 2s (within 0.8 m). Besides, the body temperature information of the staff is also the focus of entrants, so the symmetry of the information between the staff and the entrants should be ensured; ③ Mask recognition: the entrants can be identified whether they wear masks correctly, and

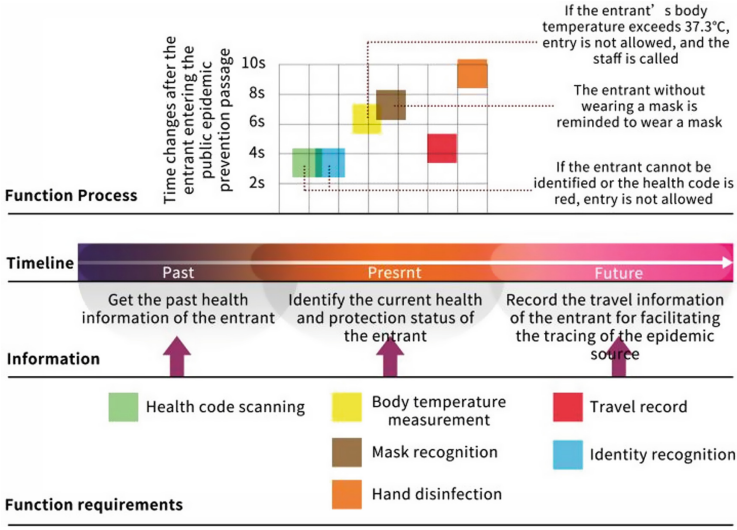

Fig. 1. Analysis of Design Requirements of the Public Epidemic Prevention Passage.

preparations for epidemic prevention in public spaces should be well performed. The AI visual recognition technology used can quickly recognize whether the entrant wears a mask effectually; ④ Hand disinfection: The hand is the part of the human body with the most direct contacts with external objects. Disinfection should be carried out frequently during the movement of people to reduce the possibility of virus carrying and spreading. The non-high temperature atomization technology adopted can make use of the vacuum suction effect to atomize the disinfectant into micron-level aerosol drops, and spray it evenly to the human hand. This technology can effectively retain the active ingredients of the disinfectant; ②③④ functions can tell the current health and protection status of the entrant. ⑤ Identity recognition: Identity recognition can be performed with health codes, ID cards, Hong Kong and Macao passports, or passports, providing tags for the storage of relevant information; ⑥ Travel record: The current location and time of the entrant are recorded; ⑤⑥ functions aim to record the travel information of entrants, which facilitates the rapid tracing of the epidemic source. ①②⑤⑥ functions can be linked to the national epidemic prevention database through data collection and storage. Especially in the post-COVID-19 era, in the event of a local outbreak, the epidemic prevention database can be helpful for rapid epidemic analysis, traceability and prediction (Fig. 1).

4.3 Comparison of the Use Process of the Public Epidemic Prevention Passage

On the basis of the design requirement analysis, the passage use process transforms some behaviors from active operations to passive operations of users with combining the technological realization path, and merges some of the entrants' behavioral steps. As a result, the function realization mode with a non-linear behavior pattern is realized, and the time and operation steps of entrants staying at the entrance and exit of the public epidemic prevention passage are shortened (Table 1).

Table 1. Comparison of the use process of the public epidemic prevention passage.

Linear behavior pattern	**Entrant behavior**		**Behavior characteristics**
	Step 1	Check the body temperature	Active
	Step 2	Check if the mask is worn	Active
	Step 3	Check the health code	Active
	Step 4	Register personal and travel information	Active
	Step 5	Disinfect hands	Active
Non-linear behavior pattern	Step 1	Scan the health code	Active
		Record personal and travel information	Passive
	Step 2	Check if the mask is worn	Passive
		Check the body temperature	Passive
	Step 3	Disinfect hands	Active

Fig. 2. Scheme of the Public Epidemic Prevention Passage.

4.4 Design Scheme of the Public Epidemic Prevention Passage

In view of the normalized COVID-19 epidemic prevention requirements, this design of the public epidemic prevention passage creates a solution with public value. By integrating the existing design requirements with the technology paths, the design optimizes the use flow of entrants, improves the use experience and evaluation of entrants and the effectiveness of epidemic prevention, and meanwhile greatly reduces the labor cost (Fig. 2).

By integrating the existing generally recognized epidemic prevention steps and contents into the integrated design of the passage, the design scheme realizes unmanned, non-contact intelligent epidemic prevention detection. Before entrants enter the detection zone, they will be guided in advance to display their health codes or take out their ID cards. QR code, ID card, passport can be identified in the scanning area, and the travel information will be uploaded to the database to form the file of user's travel data chain; when entrants are in the passage for 3 ~ 5s, the infrared thermal imager and AI visual recognizer at the top of the passage will detect human body temperature and mask-wearing condition. If the entrant has a high body temperature, the passage will sound the alarm and notify the staff. If the entrant does not wear a mask, the passage will also sound the alarm. If no abnormality is detected, the display area at the top of the passage will display a green pass sign; after passing the detection, the entrant can put his or her hands on the disinfection areas on both sides of the passage for disinfection. Once sensing the hand, the disinfection area will evenly spray an appropriate amount of atomized disinfectant. Disinfection of high-frequency contact parts of the human body can effectively reduce the efficiency of virus spreading.

The design scheme can be adapted to various scenarios and environments in practical uses, for example, combining functions such as baggage security check. The scheme can concretize the form of public epidemic prevention passage and calculate the number of devices based on the flow of people.

5 Conclusions

Taking COVID-19 epidemic prevention as an example, this paper analyzes the regional particularity of the Greater Bay Area and its public epidemic prevention requirements, and puts forward public epidemic prevention design principles for coping with public health emergencies in the Greater Bay Area with considering the current situation that the capabilities of coping with public health emergencies need to be improved in the Greater Bay Area. The public epidemic prevention passage is designed based on these principles, and the design scheme has certain technical advantages and operability in practical uses, which can provide the technical path support for improving the epidemic prevention capacity in the Greater Bay Area.

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