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Construction of Emergency Adaptability Evaluation Index System for High-Rise Residential Buildings Based on Major Public Health Emergencies

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Abstract: With the continuous variation and increasing infectivity of novel coronavirus, people are forced to stay at home for a long time, and their lives and lives are constantly threatened by the virus. In order to provide scientific basis for evaluating and optimizing the epidemic prevention and control capability of high-rise residential buildings under public health emergencies, the evaluation index system of emergency adaptive performance of high-rise residential buildings is constructed. First of all, this paper uses Delphi method to consult experts in the form of questionnaire survey, and determines the framework of evaluation index system through two rounds of index screening process. Then use the analytic hierarchy process to determine the weight value of the evaluation index system, and finally check the consistency of the index weight. As a result, the emergency adaptation performance evaluation system of high-rise residential buildings under public health emergencies is obtained.

Keywords: Public Health Emergency; High-Rise Housing; Delphi Method; Analytic Hierarchy Process

Introduction

From the beginning of the outbreak in Wuhan to the complete closure of Shanghai today, there is still a phenomenon of large-scale spread of the epidemic all over the country[1]. The outbreak of novel coronavirus had a great impact on people's life and life safety,because of the wide spread and strong infectivity of the epidemic[2], people were forced to start a long life of home isolation. High-rise housing is one of the important living forms in the urban development of our country. How to improve the adaptability of high-rise residential buildings under public health emergencies has become an urgent problem to be solved[3].

1. The characteristics of high-rise residential buildings and the restrictive factors under the epidemic situation

After entering the 21 century, China began large-scale urban construction, and the number of high-rise residential buildings is also growing rapidly[4]. High-rise residential building is one of the effective ways to solve the contradiction between human and land. According to the Code for Housing Design： 7-9 floors are medium-and high-rise residential buildings, and 10 floors and above are high-rise residential buildings[5]. High-rise residential buildings generally adopt the structure of frame shear wall, which is usually divided into two types: plate type and tower type. Among them, the plate high-rise residence is long from east to west, short from north to south, and the plane is rectangular, which is composed of a number of units and each unit is provided with stairs and elevators. Tower high-rise housing mainly refers to the shared stairs, elevators as the core, around the public transport space layout of multiple high-rise residential buildings.

Although high-rise housing can solve the contradiction between people and land, it has become a malpractice during the epidemic because of the large population. Due to the high population density and the single mode of travel, the residents can only enter and leave the house through the narrow elevator space or corridor space, which makes the virus more likely to cross-infect in the interior space of the house.In addition, the ventilation, lighting and other deficiencies in the building environment of high-rise residential buildings make it become a restricting factor for people's epidemic prevention and control, life safety and health during the epidemic.

2. Selection process of emergency adaptation performance evaluation index system for high-rise residential buildings

2.1 Hierarchical framework of index system

Based on the development characteristics of high-rise residential buildings and the influencing factors under the epidemic situation, the evaluation index system framework of emergency adaptation performance of high-rise residential buildings based on major public health emergencies is established according to the hierarchical structure：

1) Target layer: the overall evaluation of emergency adaptation performance of high-rise residential buildings based on major public health emergencies, indicating the impact of index factors on high-rise residential buildings.

2) Criterion layer: through the induction and summary of recent literature through literature analysis, the index experience is pre-selected, which is preliminarily divided into three levels: intelligent design, residential environment and space design.

3) Index layer: according to the design principle of the index and the setting of the criterion layer, the influence intensity of the influencing factors in each operation stage is evaluated.

2.2 Comprehensive evaluation and screening system for expert consultation

This study selected 10 experts from universities and design institutes, as well as 5 high-level residents with university degree or above who worked in related industries to form an expert group.

Table 1 Basic information of experts

Project	classification	Numberof people	Constituent ratio（%）
Gender	Male	9	60
	Female	6	40
Age	30-40	3	20
	41-50	9	60
	Above 51	3	20
Degree	Undergraduate course	5	33
	Master's degree	7	47
	Doctoral graduate student	3	20
Engage in the field	Design of high-rise residential buildings	3	20
	Fine design of residence	2	13
	Building physical environment	2	13
	Research on architectural technology	2	20
	Architectural design and research institute	2	13
	Construction aspect	4	27

3. Screening results of emergency adaptation performance evaluation system for high-rise residential buildings

3.1 Determination of the framework of index system

In the first round, 15 questionnaires were sent out, 15 were recovered, 15 were valid, and the recovery rate of valid questionnaires was 100%. The situation of the second round of the questionnaire is the same as that of the first round. Then the results of the previous and second surveys were analyzed and sorted out and fed back to 15 experts for reference. The effective recovery rate of the questionnaire is in accordance with the statistical law. According to the results of expert

consultation, the framework of emergency adaptation performance evaluation system of high-rise residential buildings under sudden public health is finally determined.

Table 2 Index framework of evaluation system

Evaluation system of emergency adaptation performance of high-rise residential buildings				
Total target layer A	Criterion layer B	Sub-rule layerC	Index layer D	Index description
Emergency adaptation performance Evaluation of High-rise Residential buildings	Health and epidemic prevention	Indoor hygiene of residence	Indoor disinfection facilities	Perfect disinfection equipment, equipped with alcohol and other tools
			Domestic garbage	The garbage is hidden and the transportation streamline is independent
			Locker	Masks, clothing, shoes
			Hand sink	Porch, kitchen, bathroom
		Public area health	Publicdisinfection facility	The facilities in the corridor and elevator are perfect
			Public dustbin	Garbage cleaning and disinfection speed, garbage disposal streamline
			Exhaust degree	Adequate ventilation equipment
		Hygiene at the bottom entrance	Disinfection facility	Perfect disinfection equipment at the entrance
			Public mailbox	Disinfect regularly and pick up mail in different periods
			Public handrail	Regular disinfection to reduce direct contact
			Sundries	Less sundries and open space
	Space design	Applicability of public areas	Entrance and exit space	Set up a canopy
				Entrance setting platform, ≧1500mm
				The door is opened in a non-contact manner
				Have good light

			Aisle space	The wheelchair turning space is set up in the node and near-end position
				Corridor width≧1200mm
			Vertical traffic void	At least one elevator size≧1500mm*1600mm,Clear width of car door≧900mm,Can hold stretcher
				The elevator is equipped with ventilation equipment
				Net width of stair run≧1100mm、Platform width≧1200mm
		Applicability of condom space	Functional integrity of condom	Lying, kitchen, bathroom are complete
				Set up other functional spaces such as porch, storage, balcony
			The rationality of the layout in the suit	The condom contains the transition space for entering the home
				The spatial layout is compact and the streamline is reasonable
				At least one bedroom contains a bathroom
				Bathroom dry and wet separation setting
				The bathroom is arranged near the bedroom
				Water seal depth of "reverse bend" of floor drain and water supply and drainage≧5cm
			Practicability of functional space	The shape of the functional space is reasonable and the ratio of the length to the short side of each space≦1.8

				Rational distribution of functional space area
				The internal design of the functional space is reasonable
		Flexibility of condom space	Temporary isolation space	It can be closed as a separate isolation space during the emergency period
			Removable space	There is space for temporary transformation to meet the needs of the family
				Has a transformable independent porch space
	Physical environment	Public space environment	Public area light environment	Natural lighting is good artificial lighting and local lighting are good
			Air environment in public areas	Good natural ventilation and good ventilation
		Indoor environment	Indoor light environment	Good orientation,ratio of living room to bedroom window to floor≧1/7
				Have good natural lighting and sunshine
			Indoor thermal environment	The heating and air conditioning system has good performance
				Local heating equipment is installed in shower room
			Indoor air environment	The natural ventilation in the sleeve is good
				The kitchen has natural lighting and is equipped with mechanical ventilation and check valves, and bathrooms are equipped with mechanical ventilation and check valves

				Set up fresh air system and air quality monitoring and purification equipment
			Indoor visual environment	Avoid line of sight interference, good field of vision
	Intelligent design	Intelligent design of public area	Entrance hall	Cell door face recognition is opened to reduce contact
				Intelligent temperature measurement and body condition detection at home
			Public aisle	Artificial lighting intelligent turn on
				Set up mechanical exhaust system
			Vertical traffic	Artificial lighting intelligent turn on
				The elevator is equipped with intelligent voice to open and reach the floor to reduce contact
				Independent ventilation system is installed inside the elevator to monitor the air quality intelligently
		Indoor intelligent design	Doors and windows	Intelligent opening of door-to-door face recognition to reduce contact; intelligent detection of body temperature data
				Windows open intelligently to meet the daily needs of natural ventilation and sunshine
			HomeAppliances	Artificial lighting intelligent voice or induction control, household appliance

				intelligent control system
				Intelligent Design of Independent fresh Air system
			Furniture	Intelligent design of furniture to meet the diverse needs of family life and increase spatial variability

3.2 Determination of Index weight and consistency Test by Analytic hierarchy process

By using the analytic hierarchy process, the elements of each level are compared, and the questionnaires of each expert are summarized to obtain the evaluation matrix of each level, so as to find out the weight of each level and determine the scoring weight of each expert. and the average value of the same index is calculated, and for quantitative decision-making, the 1-9 scale method is used to determine the importance of each element. According to the judgment matrix, the vector $\overline{W}i$ of the matrix is calculated, and the vector $\overline{W}i$ is normalized to get the eigenvector, that is, the index weight .

$$\overline{W}i = \sqrt[n]{\prod^{n} Aij} \qquad \overline{W}i$$

In order to prevent the weight deviation caused by the inconsistency among the factors in the judgment and evaluation, the change of the eigenvalue of the matrix is used to detect the consistency among the factors. Through weighted calculation, the maximum eigenvalue of the matrix is obtained λmax, the consistency index CI is obtained, and the relative consistency index CR is obtained. if $CR \leqq 0.10$, the matrix is reasonable, there is no contradiction in the scoring process, and the weight result of the index in the matrix is established. If $CR > 0.10$, the consistency test of the matrix fails, and experts need to re-score and repeat the above process until $CR \leqq 0.10$. Through the calculation and statistics of the data of each expert, the average value of all the data of the same index is calculated, and the final weight of the index is obtained.

Table 3 Calculation result of weight of evaluation system

Totaltarget layerA	Criterion layerB	BWeight	Sub-rule layerC	C Weight	Index layerD	DWeight
Emergency adaptation performance Evaluation of High-rise Residential buildings	Health and epidemic prevention	0.4176	Indoor hygiene of residence	0.2776	Disinfection facility	0.1236
					Domestic garbage	0.0339
					Locker	0.0177
					Hand sink	0.0639
			Public area health	0.0958	Disinfection facility	0.0522
					Public dustbin	0.0128
					Exhaust degree	0.0308
			Hygiene at the bottom entrance	0.0441	Disinfection facility	0.0213
					Public mailbox	0.0072
					Public handrail	0.0128
					Sundries	0.0029
	Space design	0.2520	Application of public areas	0.0295	Entrance and exit space	0.0039
					Aisle space	0.0054
					Vertical traffic space	0.0101
			Applicability of condom space	0.1495	Functional integrity of condom	0.0842
					The rationality of the layout in the suit	0.0341
					Practicability of	0.0312

					functional space	
			Variability of condom space	0.0730	Temporary isolation space	0.0589
					Removable space	0.0141
	Physical environment B3	0.2164	Publicspace environment	0.0419	Public area light environment	0.0201
					Air environment in public areas	0.0219
			Indoor environment	0.1745	Indoor light environment	0.0388
					Indoor thermal environment	0.0309
					Indoor air environment	0.0864
					Indoor visual environment	0.0184
	Intelligent design	0.1141	Intelligent design of public area	0.0361	Entrance hall	0.0110
					Public aisle	0.0054
					Vertical traffic	0.0196
			Indoor intelligent design	0.0780	Intelligent doors and windows	0.0378
					Intelligent household appliances	0.0273
					Intelligent furniture	0.0130

4. Conclusion

In this study, on the basis of literature review and summary of the characteristics of high-rise housing and the restrictive factors under the epidemic situation, the Delphi method is applied to construct the system. The emergency adaptive performance evaluation system of high-rise residential buildings under public health emergencies constructed by this method is scientific and practical, and can be used to evaluate the degree of health and epidemic prevention, spatial design, physical environment and intelligent design of high-rise residential buildings. in order to provide some help to the transformation and optimal construction of high-rise residential buildings under the epidemic situation. The goal of the next stage of this study is to use the constructed system to score some high-rise residential buildings under the epidemic, to divide the safety degree of residential buildings under the epidemic situation in a gradient, and to verify the scientificalness and feasibility of the indicators.

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