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Vulnerability Assessment of Old Residential Areas under the Impacts of COVID-19: A Case Study in Yinhang Area, Yangpu District, Shanghai

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Abstract: Residential areas have played a vital role in organisation, coordination, management and service in the fight against COVID-19, but they are also high-incidence areas of the epidemic. In particular, the old residential areas, as a major urban weakness during the epidemic in Shanghai, have also become the focus of scholars in many fields in recent two years. The solution to making up for the shortcomings of old residential areas has become one of the urban development issues that should be put on the agenda in the post-epidemic era. This article aims to provide ideas for the subsequent renovation of old residential areas through the analysis. It first verifies the vulnerability of old residential areas in Yinhang Area, Yangpu District, Shanghai under the impact of COVID-19 through correlation analysis and then explores its contributing factors by semi-structured interviews. The factors can fall into four categories: physical environment, population composition, residential management, and social capital.

Keywords: vulnerability assessment, correlation analysis, semi-structured interview

1. Introduction

From March to June 2022, the novel coronavirus epidemic hit Shanghai, bringing great challenges and enormous social and economic costs to the city [1]. According to the barrel theory, a common problem faced by any system that could ultimately determine the system's overall level is the weakest weak board. Therefore, in the post-epidemic era, exploring and reflecting on the weaknesses of cities and making improvements is inevitable for cities to face the impact of future unknown disasters better and achieve sustainable urban development.

The old residential areas are those constructed before the year 2000. And the background is that in the 1980s and 1990s, because of the urgent need to solve housing problems, Shanghai built a large number of residential areas. However, limited by the economic level at that time and in order to accelerate construction, these residential buildings often have low construction standards, incomplete supporting facilities, and a lack of long-term management mechanisms. Currently, they face problems such as ageing infrastructure and ageing population.

During the epidemic, not only various news reports but also the epidemic reports by the spokesperson of the Shanghai Government focused on the issue of old residential areas as one of the difficulties in the prevention and control of the epidemic. For example, China Youth Daily reported

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330 old residential areas in Huangpu District, accounting for about 57% of the total residential areas, involving 250000 residents. These old residential areas were difficult points for epidemic prevention and control.

Yinhang Area, Yangpu District, Shanghai was officially established in April 1985 and was developed in the mid to late 1980s. It is currently the largest residential area in Shanghai. This article uses statistical analysis methods to evaluate the vulnerability of old residential areas in Yinghang Area, Yangpu District, Shanghai, and analyses the contributing factors of the vulnerability of old residential areas.

2. Principles of Vulnerability Assessment of Old Residential Areas

2.1. Definition of Vulnerability

The concept of vulnerability originated from natural disaster research. Peter Timmerman first proposed the concept of vulnerability in geology, and it has been widely applied in various fields, such as ecology and sociology. Vulnerability research has become a trending topic and an important analytical tool for global environmental change and sustainable development [2]. Based on existing research, vulnerability refers to the exposure, sensitivity and adaptive capacity when the old residential areas face an emergency (taking the epidemic as an example) in this article. Sensitivity is the degree to which people in the old residential areas are likely to be affected by epidemic-driven changes; adaptive capacity is the adaptive options and resource management strategies employed to address crises [3].

2.1. Vulnerability Assessment Logic

As for the relationship between crisis and vulnerability, it is generally believed that the crisis may not occur in areas with low vulnerability in the face of the same hazard. In contrast, the likelihood of crisis in areas with high social vulnerability will increase [4]. Therefore, if the set data indicates a significant increase in exposure and sensitivity of old residential areas under the same disaster-causing factors (epidemic), they are considered more vulnerable.

3. Methods

According to the definition of vulnerability, we use the total number of confirmed cases and the increase in confirmed cases to measure sensitivity for quantitative analysis during the epidemic. The data collection period was from March to June 2022 because this period presented a complete process of Shanghai epidemic from the outbreak, large-scale spread, and government zoning control to return to normal life (Table 1).

3.1. Data Sources

Based on the accessibility of relevant data, the Yinhang area in the Yangpu District of Shanghai is selected as the analysis sample.

3.2. Data Processing Methods

3.2.1. Correlation Analysis

The Pearson correlation coefficient (R) is obtained by estimating the covariance and standard deviation of the sample.

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Table 1: The Collected data in the Yinhang area in the Yangpu District of Shanghai.

Neighbourhood	Total number of confirmed cases	Increase in confirmed cases(%)	Floor Area Ratio	Housing Price (10,000yuan/$m^{2)}$	Property Management Price(yuan/m^2)	Completion Year
Neighbourhood1	189	39	2.5	10	0.8	1987
Neighbourhood2	133	36	2.3	6.79	0.55	1988
Neighbourhood3	108	26	2.3	5.7	1.2	1984
Neighbourhood4	104	29	2.1	6.3	0.9	1992
Neighbourhood5	95	31	2.2	6.7	0.26	1985
Neighbourhood6	92	25	1.9	6.4	0.8	1990
Neighbourhood7	88	26	1.9	8.85	2	2006
Neighbourhood8	73	25	2.1	4.3	0.8	2009
Neighbourhood9	64	24	1.9	1.78	0.7	1008
Neighbourhood10	57	23	2.1	8.66	0.8	2005
Neighbourhood11	52	24	1.8	5.8	0.6	2014
Neighbourhood12	48	18	1.8	6.79	1.75	2014
Neighbourhood13	38	17	1.2	7	0.8	2017
Neighbourhood14	33	19	1.8	10	0.6	2009
Correlation Coefficient (R)	Total number of confirmed cases		0.8841	0.1283	-0.3310	-0.8499
	Increase in confirmed cases		0.9182	0.0415	-0.5145	-0.8161

The value of this coefficient is between [-1,1]. These two variables are positively correlated when the value is greater than 0. The closer the value is to 1, the stronger the correlation; When the value is less than 0, the two variables are negatively correlated, and the closer the value is to -1, the stronger the correlation.

3.2.2. Sensitivity Analysis

This article compares the old residential area in Yinhang Area, Yangpu District, Shanghai and its nearby new residential areas. The total number of confirmed cases and the increase in confirmed cases in the residential areas are used as quantitative indicators for sensitivity assessment, and correlation analysis is conducted with relevant factors that may have an impact on sensitivity, such as residential construction time, floor area ratio, housing prices, and property fees. Due to the

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difficulty in evaluating exposure using quantitative indicators, sensitivity is the main aspect of measuring residential vulnerability in the article.

4. Results

When the absolute value of the correlation coefficient between two variables is greater than 0.8, it indicates a strong correlation between the two variables (Figures 1, 2). As shown in the table, there is a strong correlation between the total number of confirmed cases and the year of construction, the total number of confirmed cases and the floor area ratio of the residential area; There is a strong correlation between the increase in the number of confirmed cases and the year of construction, the increase in the number of confirmed cases and the floor area ratio of residential areas.

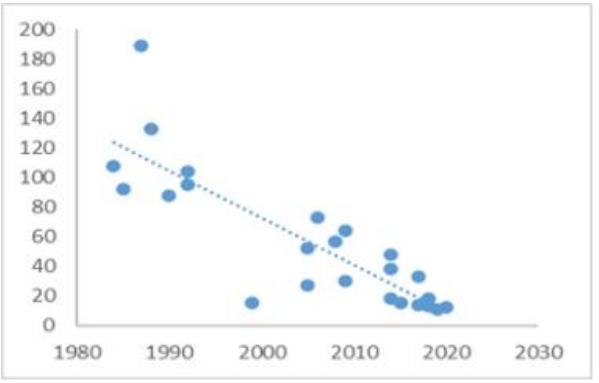

Figure 1: Correlation between total confirmed cases and construction year.

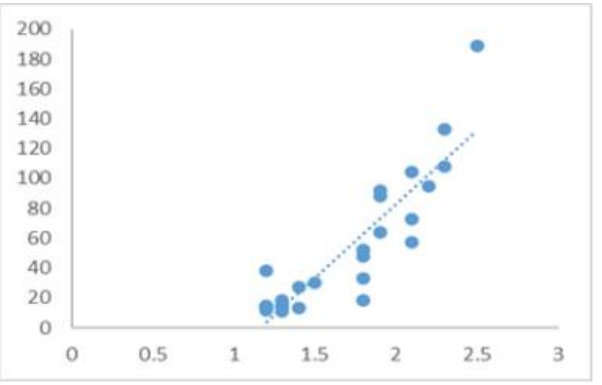

Figure 2: Correlation between total confirmed cases and floor area ratio.

It can be concluded that the earlier the construction time of residential areas, the stronger their vulnerability, which means that old residential areas are generally more vulnerable. At the same time, residential areas with larger floor area ratios are often more vulnerable.

5. The Contributing Factors of Vulnerability of Old Residential Areas During the Epidemic

Based on obtaining first-hand information through semi-structured interviews in the target residential area, this article uses relevant vulnerability assessment and analysis frameworks to sort out, classify, and analyse the key factors that determine the vulnerability of old residential area under the impact of the epidemic.

5.1. Semi-structured Interview

Semi-structured interviews aim to identify residents' primary concerns during the epidemic, help to focus on main issues and understand residents' views and suggestions on future improvement. Since the rate of population ageing within the residential area is as high as 42%, more attention has been paid to the elderly residents.

In the first round of interviews, a total of 15 respondents, including 7 older people, 3 middle-aged people, 3 young people (including 2 tenants), and 2 people working at the committee of this area, were asked a relatively open-ended question: What is the biggest impact and change that the epidemic has had on the lives of residents in your neighbourhood?

The interview results indicate that the elderly are mainly concerned about the following four issues: (1) Lack of access to the medicine during the lockdown period of the epidemic; (2) Helplessness because they’re digital refugees; (3) Panic and loneliness; (4) Lack of corridor cleaning. The issues

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are further concretised, including 10 questions about the current situation and their expectations in these 4 aspects (Table 2).

Table 2: Questions about the current situation and their expectations.

Topic	Sub-topic	Questions
The Accessibility to Medicine	Current situations	1. What do you think is the biggest difficulty in dispensing medicine? 2. Are there many places nearby where medicines can be dispensed?
	Expectations	3. Do you have any suggestions and good ways to improve the dispensing?
Corridor Sanitation	Current situations	4. What do you think are the problems with the apartment building?
	Expectations	5. How do you want to improve the corridor?
Digital Refugee	Current situations	6. During the lockdown, have you ever had problems buying groceries because you don't know how to shop online? 7. How did you overcome such a difficulty?
	Expectations	8. How do you hope to get help?
Loneliness and Panic	Current situations	9. How did you feel during the epidemic?
	Expectations	10. What kind of methods do you think can relieve bad emotions?

The interview results indicate that: (1) Elderly residents hope there will be more places nearby where basic medical services are available, such as community hospitals. (2) Elderly residents tend to seek help from young people regarding the use of digital devices. (3) Chatting with peers is an important way for elderly residents to get rid of anxiety and find inner peace.

5.2. The Influence Factors of Vulnerability of Old Residential Areas

Generally speaking, the assessment and analysis of residential area vulnerability involve three dimensions: exposure, sensitivity, and adaptive capacity, and there are numerous models for comprehensive vulnerability evaluation [5-7]. The research in this paper mainly focuses on the vulnerability analysis of old residential areas under the impact of COVID-19, a public health event. Various constituent structures in the residential area exposed their weaknesses or defects in the face of disaster-causing threats. Therefore, based on the research objectives and comprehensive analysis of relevant research, this article divides vulnerability analysis into four categories: physical environmental factors, population factors, management factors, and social capital factors.

5.2.1. Physical Environmental Factors

(1) Traditional design of sewers in old residential areas

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The ageing of old residential areas is first reflected in the ageing of infrastructure, among which the blockage of sewers and the lack of ventilation equipment are major factors in weakening the sensitivity of old residential areas in this epidemic and expanding the scope of virus transmission. For respiratory viruses like COVID-19, if the drainage system of the sewer is not tightly sealed, the human body may become infected by inhaling pollution particles formed in the sewage pipe. Old houses with poor drainage systems may cause the spread of aerosols because of the constant sewer backflow.

However, the unfavourable factors of frequent blockage, poor sealing, and poor ventilation of the bathroom sewer often put the old residential area at a distinct disadvantage. Firstly, during construction, the bathroom's toilet and floor drainage pipes used an L-shaped sink instead of a conforming U-shaped sink. Even if a U-shaped sink was installed, no anti-siphon suction valve was installed, resulting in the water in the sink being sucked away, thus increasing the risk of bacteria entering the house. Secondly, most old residential areas do not have ventilation equipment or fans without check valves, which can cause the discharged gas to flow back and be contaminated by virus gas, making it difficult to ensure good fresh air circulation between the bathroom and outdoor areas.

(2) The density and ventilation conditions of old residential buildings

The floor area ratio of multi-story residential areas, whose apartment buildings are less than 6 floors, built in recent years usually does not exceed 1.5, while the arithmetic means of the floor area ratio of old residential areas investigated in this paper is as high as 2.1 because the living quality of residents is not the key point of consideration at the beginning of construction. According to existing research, Ren et al. observed that the high-risk areas for COVID-19 infection in Beijing and Guangzhou tend to occur in areas with high population density [3], while the building density will lead to poor ventilation, which will inevitably facilitate the spread of COVID-19, whose spread depends on air and aerosol transmission.

(3) Limited living conditions in old residential areas arrest effective isolation

An apartment is the smallest unit in a residential area and the smallest for epidemic prevention. During severe home quarantine due to the epidemic, the apartment became the only living space in the short term. However, the characteristics of one elevator, multiple households, and small units in old residential areas mean more cross lines between households and among family members, resulting in a higher probability of infection among each other.

(4) The lack of public space in old residential areas

The public space in old residential areas was initially planned to be small and is often occupied or misused. For example, at the beginning of construction, people had a relatively small demand for parking space, resulting in insufficient land for parking when planning. However, nowadays, with one or more vehicles per household, motor vehicles occupy most of the public space; In addition, the existing small and scattered public spaces in old residential areas, such as the edges of residential buildings, are often covered with household waste and not fully and reasonably utilised. These negative public spaces lose their original flexibility and openness, indirectly reducing the possibility and willingness of neighbourhood communication within the residential area. The alienation between residents and the weakening of information circulation will inevitably lead to a psychological panic about the unknown in the epidemic.

(5) The lack of accessibility to community hospitals in old residential areas

During the lockdown of the COVID-19 epidemic, the shortage and imbalance of medical resources are particularly prominent. The high-quality medical resources in Shanghai and even in China are mainly concentrated in tertiary hospitals, which are most patients' first choice regardless of the severity of their illness. According to an official report from the National Health Commission, tertiary hospitals, which account for only 8.9% of the total number of hospitals in China, undertook 57% of the outpatient consultation of hospitals nationwide in 2021. However, community hospitals have not fully utilised their necessary diversion capabilities as the most grassroots level of graded diagnosis

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and treatment. Generally, more than 80% of problems in the UK can be solved except for severe emergencies. For elderly people suffering from chronic diseases in residential areas during the peak of the epidemic, it is inconvenient to enter and exit the residential area because of the lockdown management and the spread of the virus. Secondly, even if access is free, the prolonged queuing in tertiary hospitals for medication is not friendly to the physical condition of the elderly.

5.2.2. Demographic Factors

(1) High rate of population ageing, with residents' low cognition, physical strength

In the old residential areas, the population ageing rate is as high as 42%. In this epidemic, digital integration is quite tricky for the elderly. Firstly, older people have weaker learning and cognitive abilities due to physiological ageing of the body; Secondly, due to the rapid changes of the times, learning to use digital products is behaviour outside the comfort zone of the older generation, so their willingness to learn new things is relatively low; Finally, as the core and empty-nest family are becoming a trend in China, elderly families lack effective family care and assistance, and thus their learning approach to digital products are also limited. The insufficient capacity to adopt electronic products and lack of online social ability among elderly people greatly reduces community management efficiency and their ability to self-rescue.

(2) Tenants and the population stability

The characteristics of old residential areas, such as ageing infrastructure, incomplete public service facilities, lack of property management, and smaller-size apartments, determine the low quality of life and low cost of living in these areas, which attracts many migrant workers, meeting their needs of both having space to settle down and save expenses. However, a large number of tenants and strong mobility in residential areas inevitably make it more difficult for neighbourhood committees and property owners to obtain and manage population information.

5.2.3. Management Factors

(1) Poor professional ability of the neighbourhood committee

The neighbourhood committee plays a role in the Shanghai community's epidemic prevention and control, managing, mobilising, and implementing decisions, and is the centre of the community's epidemic prevention and control. Due to its strong administrative characteristics, it has resulted in more orders being issued in practical work (e.g., government decisions, regulations, requirements, and information being conveyed downwards) and less information reporting to the superior (e.g., public opinion, difficulties, residents' needs being reported to superiors); More management (e.g., implementing superior management requirements through mandatory means), and less mobilisation (e.g., to mobilise residents' enthusiasm and participation both emotionally and rationally); More implementation (e.g., implementing management work at superiors' requirements), and less decision-making (e.g., combining superiors' requirements with neighbourhood's situation, creatively carrying out work). At the same time, the staff of the neighbourhood committee lacks relevant training and necessary knowledge in disaster response, resulting in defect in decision-making, management, and implementation in the disaster response.

(2) Unclear positioning and responsibilities of the property management company

The property management company of neighbourhood is not only a company, but also bears the responsibility of neighbourhood public services, and is a unity of profitability and public nature. On the one hand, at the early stages of the government's disaster response, the property management company was not included in the public management, and thus it was denied public service authorisations such as information synchronisation, which affected the normal operation of property management and subsequently affected public health and management in the neighbourhood. On the

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other hand, some property management companies neglected their responsibilities as public service bodies when facing the epidemic, resulting in inadequate work, unfilled vacancies, and failure to fully play their roles.

5.2.4. Social Capital Factors

Social capital is about the value of social networks, bonding similar people and bridging between diverse people, with norms of reciprocity [8]. Generally, community social capital is formed in the common process of community life among residents. When disasters occur, community social capital can help community residents watch and help each other, overcome difficulties together, reduce disaster impacts, and improve their post-disaster recovery ability, benefiting individuals.

(1) The rapid changes in social structure

Neighbourhood interaction is decreasing daily, and informal neighbourhood networks, special reciprocity, interpersonal trust, and a sense of community belonging are common problems both new and old communities face. The reality of the epidemic indicates that strengthening interaction and familiarity among neighbours, increasing willingness to help each other, and a sense of community belonging is particularly important for old communities.

(2) Lack of development of public welfare elderly care service organisations

The author found that in several residential areas, mutual assistance behaviour between families of young children (mainly preschool children and elementary school children) is more common, such as temporary care or pick-up and drop-off of children between each other. The common needs of caring for young children promote mutual assistance and cooperation among residents, forming reciprocal norms and giving birth to mutual aid organisations such as 3:30 School and Trusteeship Class and educational community service organisations [9]. However, the spontaneity and resident participation of public welfare elderly care service organisations are relatively low. Organising people to provide services for more elderly needs to be solved.

6. Conclusion

This paper analyses the vulnerability of old residential areas in Yinhang Area, Yangpu District, Shanghai, under the impact of COVID-19 and its contributing factors.

Firstly, based on applying existing vulnerability analysis in sociology, a quantitative comparison is made between the sensitivity of old and newly built residential areas to the epidemic. Secondly, based on the results of the semi-structured interviews, the contributing factors that cause the vulnerability of old residential areas are analysed, aiming to provide future renovation ideas.

Through correlation analysis, it has been verified that old residential areas are more vulnerable to the epidemic than newly built ones. The further study focuses on the factors that affect the sensitivity and finds a strong correlation between the residential floor area ratio and its sensitivity.

Based on the ethnography method, the main reasons for making old residential areas more vulnerable can be concluded by visiting and observing the area investigated and conducting semi-structured interviews with the residents. Firstly, there are various problems with the physical environment of old residential areas. For example, the ageing of existing facilities, improper design and insufficient utilisation of public spaces, and inadequate basic medical resources. These all accelerate the spread of the virus while being unfriendly to susceptible populations, exhibiting the characteristic of a strong disaster-causing and weak carrying capacity. Secondly, a larger number of the elderly population and the tenants in old residential areas is an unfavourable factor bringing about a higher proportion of digital refugees and stronger population mobility, which have reduced the efficiency of residential management during the epidemic and the ability of the population to self-rescue. So, higher requirements for the management ability and plan of residential areas are needed.

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Thirdly, as managers of residential areas, both the neighbourhood committee and property management have failed to fully play their respective roles and take their responsibilities, resulting in inefficient decision-making and inadequate consideration in epidemic prevention and control. Finally, the changes in social network relationships, the lack of space for online and public interaction, and the lack of public participation in elderly care services make the social capital in residential areas less resistant to disasters.

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