Research Paper

Study on the mechanism of public service emergency response to public health emergencies

Take Wuhan as an example

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Abstract

With the frequent occurrence of epidemic diseases such as "SARS", "H1N1", "MERS"and"COVID-19", public health emergencies, which are characterized by large-scale, high risk, strong persistence and high risk, have become more and more obvious threats to the life and health of urban residents and put forward a huge test to the urban public service system. As the first city of COVID-19 human infection, the core of the epidemic spread and the worst-hit area, Wuhan is an ideal case study. Based on the analysis of the epidemic prevention and control actions in the first three months of the outbreak in Wuhan, this paper evaluates the vulnerability of the public service system and facilities in Wuhan. The results show that Wuhan is faced with many problems, such as the failure of community-level public service facilities, the imbalance of public service allocation in the central city, and the significant gap of graded service supply, when dealing with public health emergencies. Further studies found that due to the lack of dynamic early warning mechanism, the decoupling of public service construction from the urbanization process, the difficulty of service turnover and subsidence and other factors, the public service response was delayed. Based on these practical difficulties, this paper puts forward the construction path of the emergency response mechanism for the city level public service system, specifically including the following six key contents: (1) Improving the emergency plan path of the public service system; (2) Establishing the organizational structure of the emergency management system according to the administrative divisions; (3) Building a community-based mobilization system; (4) Establishing the regional joint defense and control interaction mechanism in public health emergencies; (5) Reserving appropriate strategic construction space; (6) Strengthening the emergency infrastructure construction. Finally, based on the path of emergency response mechanism, this paper proposes the corresponding city wide spatio-temporal prevention and control network strategy, so as to provide a reference for the realization of city health and order.

Keywords

Health equity, Major public health emergencies, Vulnerability assessment, Public service system, Emergency response

1. Introduction

From the end of 2019 to 2020, COVID-19 swept the world and becoming an "international public health emergency" (PHEIC). By the end of 24:00pm on August 1st, the cumulative number of confirmed cases in the world has reached 17,861,211 (including 88,416 cases in China, the data were confirmed by China Health Commission), the cumulative number of deaths has reached 685,550 (including 4,675 cases in China, the data were confirmed by China Health Commission), and still in a state of high-speed transmission. Looking back at the outbreak of infectious diseases such as SARS in 2003, H1N1 in 2009 and MERS in 2012,

it was found that public health emergencies of large scale, strong persistence, easy transmission and high risk have become global problems that threaten urban public safety and residents' life and health, posing a huge challenge to urban public health and public management.

As the first city with novel Coronavirus human infection, Wuhan had 49912 confirmed cases and 2370 deaths at the peak of epidemic in March, accounting for 61.8% and 76.5% in China respectively (Data confirmed by Hubei Province Health Commission). A total of 1327 communities (94.4%) and 5028 communities (70.8%) had confirmed cases in the whole city, which was a very critical disaster area for the spread of the epidemic (Data confirmed by Wuhan Health Commission). Therefore, the national emergency command has launched a series of national medical and material aid actions for emergency organizations in Wuhan, and cooperated with the service supply of urban public service system under the closed management mode, effectively promoting Wuhan from the peak outbreak to the end stage It should be recognized that urban living service facilities have a strong correlation with the transmission barrier of the epidemic, and in-depth exploration of its operating mechanism can provide valuable experience and lessons for future urban public service construction(Sangiorgio et al., 2020, Rahman and Sathi). Reviewing the three months of epidemic prevention and control, while showing the speed and strength of epidemic prevention and control, Wuhan has also exposed the problems and shortcomings of the urban life service system in dealing with major public health emergencies. Therefore, this paper focuses on the performance of the multi-level public service in Wuhan in the spread of the epidemic, in order to provide reference for the prevention and control of the epidemic in similar megacities.

2. Study area and data sources

2.1. Study area and its administrative mechanism

The scope of Wuhan's administrative management is included in this study (Figure1). Wuhan is the capital of Hubei Province, a megacity, and the only sub provincial city in six central provinces. It is also the central city of central China approved by the State Council, an important industrial base, science and education base and comprehensive transportation hub in China. By the end of 2019, Wuhan has jurisdiction over 13 districts, with a total area of 8569.15 square kilometers. Below the level of the 13 districts is a more subdivided community management unit. These community management units (Figure2), including 156 streets, 1 town, 3 townships and 2 offices, have played an important role in the fight against the epidemic.

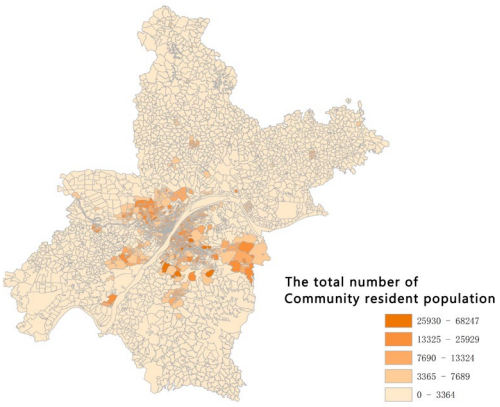


Figure 1 Satellite map of Wuhan **Figure 2 Management units in Wuhan(Including population distribution)**

2.2. Data Sources

The data collection interval is from December 2019 to March 2020. The data sources used in this paper are as follows:

(1) The total data of COVID-19 diagnosis is from Dingxiangyuan, a famous popular medical website in China (https://ncov.dxy.cn/ncovh5/view/pneumonia?source=qq)

(2) The data of community diagnosis comes from Sohu, a famous news website in China.(https://www.sohu.com/a/373530538_729208)

(3) The POI data of the facility comes from the open source excuse of Baidu map.

3. Methodology

3.1. The overall evaluation of service system: Kernel density analysis and nearest neighbour index

The kernel density calculation method is a statistical method of nonparametric density estimation. Its estimation is based on the spatial analysis method of the distribution characteristics of the research object, which can directly show the distribution probability of the research object. The level of the kernel density value represents the agglomeration degree of the research object in the spatial distribution. In the study of medical public service facilities in Wuhan, the spatial distribution pattern of medical facilities in Wuhan city is calculated according to the collected medical facilities geographic data. The Kernel density is defined as: set x1,x2 and xn are the geographical distribution samples extracted from the population samples of the distribution density function ƒ. The Rosenblatt Parzen kernel calculation model is used to estimate the value of ƒ:

$$f_n = \frac{1}{nh}\sum_{i=1}^{n} k\left(\frac{x - x_i}{h}\right) \quad (1)$$

In the formula: f_n is the measured value of the Kernel density of public services, n is the public service facilities, k is the kernel density function, $x\text{-}x_i$ is the distance between the public service facilities x and the sample public service facilities x_i, and h is the smoothing parameter of the kernel density measurement band.

On the macro scale, public service facilities can be regarded as point elements. The spatial distribution types of point elements are uniform, random and condensed, which can be identified by the nearest neighbour index. The nearest neighbour index t is defined as the geographic index of the ratio between the actual nearest distance and the theoretical nearest neighbour distance. The formula is as follows:

$$T = \frac{\overline{r_1}}{\overline{r_E}} = 2\sqrt{D} \quad (2)$$

Where: $\overline{r_1}$ is the average observation distance; r_E is the expected average distance; D is the point density. T is the nearest neighbor ratio. When t = 1, the point elements are randomly distributed; when t > 1, the point elements are evenly distributed; when T < 1, the point elements are agglomerative distribution.

3.2. The medical equity evaluation: Closest facility analysis and OD cost analysis

The equality analysis of public service facilities is divided into the following two steps. The first is closest facility analysis. In ArcGIS 10.2, the closest facility analysis option of network analysis is selected. At the same time, all communities in Wuhan are transformed from polygon elements to point elements, with a total of 5069 points. The point elements are imported into the event points set of network analysis. Secondly, medical facilities are selected as the typical representative of public service facilities in major public health emergencies, and the original data set is the point element, including various types of general hospitals, specialized clinics, and clinical hospitals, with a total of 17063. These points are then collected as

facility points of network analyst, and click the run button to calculate the distance between each community and the nearest medical facility.

The second step is to use OD (Origin-Destination) cost analysis. Similar to the above method, change the network analysis option to OD cost analysis, import the community element points into the starting point set, import the medical facility element points into the target point set, and then click the run button to get the total road cost from each community to the medical facilities, that is, to evaluate whether the layout of medical facilities in the whole city is balanced.

3.3. The evaluation of medical services: Accessibility analysis

The construction of community life circle has provided the material basis and resource supply chain for the former in recent years(Yifan, 2019, Meng, 2017, Yanwei et al., 2019). According to the Standards for Urban Residential Area Planning and Design (2018) issued by the Ministry of Housing and Urban-rural Development of The People's Republic of China, the standards for community life circle construction are as follows (table1):

Table 1 The construction scope of the three-level life circle

Distance and scale	15 minutes life circle	10 minutes life circle	5 minutes life circle
Walking distance(meter)	800~1000	500	300
Resident population (person)	50,000~100,000	15000~25000	5000~12000
Number of Residential(units)	17000~32000~5000	5000~8000	1500~4000

In the specification, the following facilities related to healthy living must or should be equipped at all levels of life circle.

- **Fifteen minutes life circle:** Gymnasiums, large multi-functional sports venues, health service centers (community hospitals), outpatient departments, nursing homes, nursing homes for the elderly, and community service centers.
- **Ten minutes life circle:** Medium multi-functional sports venues
- **Five minutes life circle:** Community service stations, small multi-functional sports venues, outdoor comprehensive fitness venues, nursing homes, community health service stations, public toilets

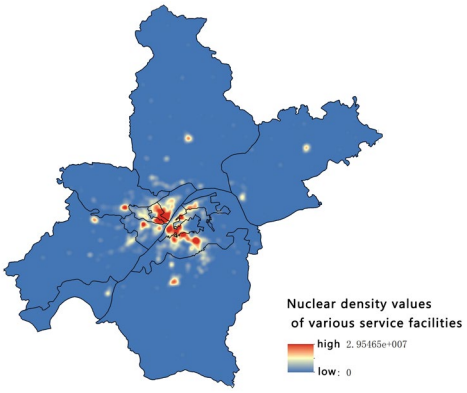
Therefore, considering the importance of transport planning for public service fairness(Ruiz et al., 2016, Ruiz et al., 2017, Qi et al., 2020), life circle as an indicator of medical accessibility will be given priority. Firstly, Wuhan road network vector data set is constructed in ArcGIS 10.2, which is derived from Baidu map extraction. Secondly, taking the medical facilities as the center, the service area of network analysis was selected for analysis. The interruption value was set at 300, 500 and 1000, and the area construction was set at 50 meters.

4. Results

4.1. The allocation of urban public service system is unbalanced

Chinese urban public service supply mode is a co-construction form of "government led, social participation, enterprise management" at the present. At the specific implementation level, the allocation mode of "core — basic — supporting " is generally adopted with administrative region and population density as the allocation standard. The Kernel density analysis shows that with the agglomeration and expansion of

metropolitan areas, the construction of urban public service system and the process of urbanization gradually appear to be incompatible, unsynchronized and mismatched. In the construction, there is a lack of foresight to deal with public health emergencies. For example, the scale and level of supporting medical, educational and cultural resources in high-density plots of Wuhan, such as Guanggu, Nanhu, and North Hankou, are significantly lower than the supply level of old urban areas such as Jianghan and Jiangan(figure3). However, according to the relevant data of COVID-19 situation in Wuhan City, it is found that the spread coefficient of epidemic situation in the newly increased high-density residential area is relatively high, which makes it a high-risk area for epidemic spread(Sun et al., 2020, Peng et al., 2020, Hu et al., 2020)(figure4). Furthermore, the proximity index of public service facilities is 0.177. As an important classification, the proximity index of medical service facilities is 0.230. The results show that public service facilities generally present agglomeration and unbalanced distribution. Under the unbalanced configuration of public service system, the urban population high density space unit is generally faced with the problems of insufficient supply of supporting public service facilities, incomplete function, response failure and so on.



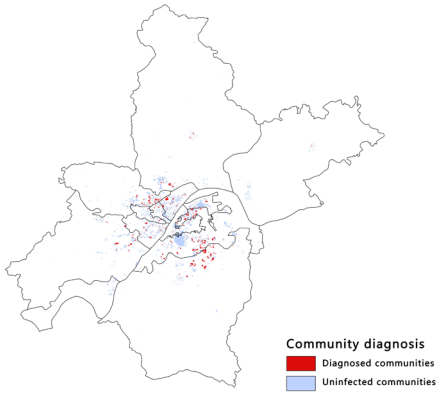


Figure 3 Kernel density of public service facilities in Wuhan **Figure 4 Epidemic area in Wuhan**

4.2. The gap of medical service support system is significant

The results of the nearest neighbor analysis calculated from ArcGIS show that the residents in the central urban area are more likely to seek medical treatment in a short distance (green part of the diagram) than in the suburban areas(figure5). A large number of short-distance groups are concentrated and evenly distributed in the central urban area, while the long-distance and short-distance groups exist simultaneously in the villages and towns in the far urban areas, and the former is the main group in quantity. Therefore, the medical facilities in Wuhan show a trend of "partial equilibrium, overall imbalance".

The overall OD analysis further shows the commuting distance between the community and various medical resources (especially the centralized medical resources in the central urban area). The results show that the distribution of medical resources is structurally unbalanced (figure6), and the cost of high od is about ten times that of low OD. Among them, three far urban areas (Dongxihu District, Caidian District and Xinzhou District) of Wuhan City have significant spatial block in obtaining superior medical resources, while the central urban area and some remote urban areas (such as Jiangxia District) are relatively easy in this aspect.

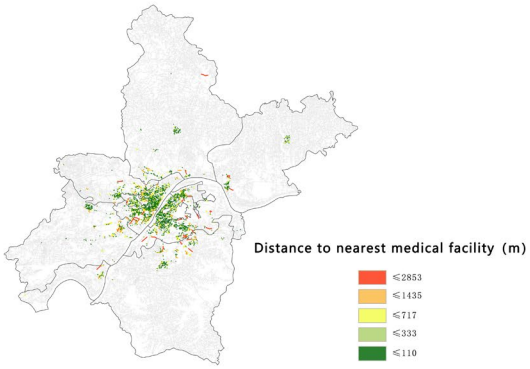


Figure 5 The Closest facility analysis results

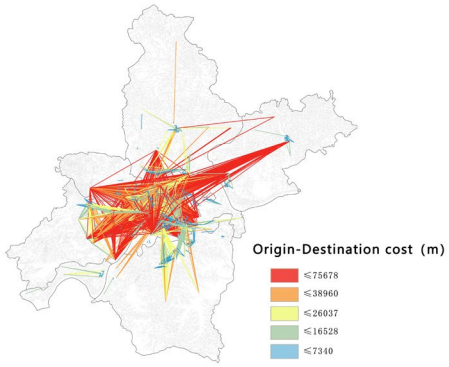


Figure 6 The OD cost analysis results

4.3. Prevention and control response failure at community level

Due to the limited supply of external rescue forces, the emergency response of the epidemic situation and the basic demands of the citizens need to rely on the internal service supply of the urban public service system. As an important carrier, organization and implementation subject of urban public service system construction, urban community is the spatial unit of isolated prevention and control. In terms of the results of community prevention and control in Wuhan (figure7). Although 79 "Uninfected residential areas" (accounting for 5.6%) and 2076 " Uninfected communities" (accounting for 29.2%) have been successfully realized under the closed management mode, there is a lack of planning and prediction and emergency reserve operation plan for dealing with public health emergencies in the actual epidemic prevention process.

Although the construction system of community life circle played a huge role in the epidemic, its effect was not obvious at the initial stage of the epidemic transmission, so there were some limitations. China's public service facilities have lagged behind residential real estate development for a long time, and there is also a lack of corresponding regulatory measures to restrict the balance of public service supply. Therefore, the construction of a perfect community life circle is a long-term process. During this period, the turnover and sinking of various services were difficult. At present, the community life circle is obviously unable to cope with the emergent public health events and other similar disasters. As shown in the figure8, according to the standard of life circle, the service scope of various medical facilities has not yet covered the epidemic area, so people cannot get treatment nearby, which increases the risk of epidemic spread.

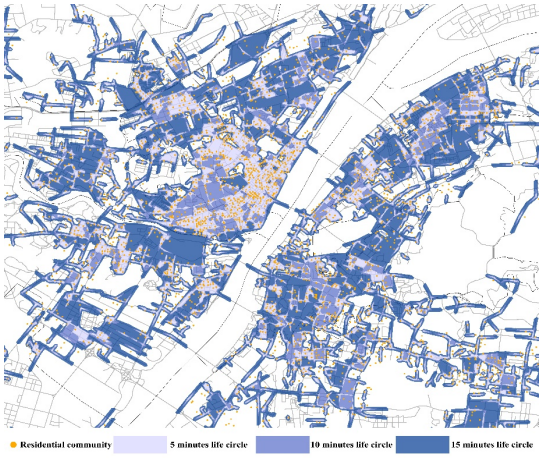


Figure 7 Life circle of central Wuhan

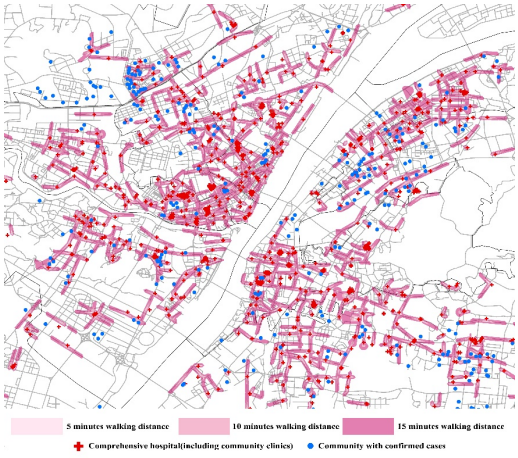


Figure 8 Coverage of medical facilities in central Wuhan

5. Discussion

In terms of the results of community prevention and control in Wuhan, although 79 " Uninfected residential areas" (accounting for 5.6%) and 2076 "Uninfected communities" (accounting for 29.2%) have been successfully realized under the closed management mode (Data confirmed by Wuhan Health Commission), there is a lack of planning and prediction and emergency reserve operation plan for dealing with public health emergencies in the actual epidemic prevention process. In terms of service capacity, due to the large scale of the city population (the average size of the central urban area is 7000-9000), the public service load is overloaded, and more than 45% of the community basic living and medical materials cannot achieve functional self-sufficiency. In terms of operation and management, due to the lack of vigilance of management personnel and self-panic of service personnel, epidemic prevention in some districts becomes a mere formality, and the transportation and distribution of life and medical materials are chaotic. Therefore, based on the above analysis, this paper gives the mechanism of public service emergency response from the three levels of city, administrative district and community.

5.1. City Level: Improving the path and management system of emergency plan

The establishment of large volume shelters is a mandatory part of the planning theme of disaster prevention system in China's urban master planning. For example, in the layout of parks, gymnasiums and squares, in addition to providing their own leisure and fitness functions, it is also necessary to consider the function of accommodating people affected by disasters (especially sudden disasters such as earthquake disasters). At the peak of COVID-19, Wuhan emptied many stadiums and added beds to turn them into mobile cabin hospital(figure9). By the end of the epidemic in Wuhan, 16 Mobile Cabin hospitals in Wuhan had treated more than 12,000 people, far more efficiently than comprehensive hospital (Meng et al., 2020). In the construction of city-level public service, it should be an important content to abandon the simple allocation of public service facilities and rediscover the functional diversity and plasticity of large volume buildings and spaces, so as to be able to cope with unknown disasters in a timely manner in critical moments. At the same time, the improvement of relevant administrative system is also very important. The municipal government should establish emergency management system (Zhu and Gao, 2013, Zhang et al., 2017) and departments to deal with the epidemic situation, so as to solve the problems of material allocation (Zhai and Zhang, 2010, Bolivar et al., 2010), economic production and prevention and control balance.

Figure 9 Wuhan mobile cabin hospital

Source: https://pic.hubeidaily.net/ and https://ctdsbepaper.hubeidaily.net/

5.1. Administrative level: Strengthening information exchange in epidemic period and reserving strategic space

In urban planning, the fair distribution of public services or public goods is regarded as the criterion to build a harmonious and stable society, and even becomes the ultimate goal of the planning. This traditional concept should evolve, because the premise of life is survival, followed by the enjoyment of services. The planning needs to consider more than just tangible public services. Therefore, the introduction of life

resources is crucial. There are two types of life resources. One type is spatial resources, such as Community clinics, venues for activities and leisure. The other is information resources, which is more important, such as information transmission between people, neighborhood communication, mutual help and so on(Shan et al., 2019). The above resources can be the building blocks of resistance to external disasters (Jung et al., 2013, Bleakley et al., 2020). In addition, reserving strategic reserve space is also instructive, as shown in the figure. There used to be no market here(figure10). Due to the principle of centralized sale of goods established by relevant regulations, volunteers sold and distributed goods to residents. Residents have access to the latest epidemic information, and also timely supplement of life supplies.

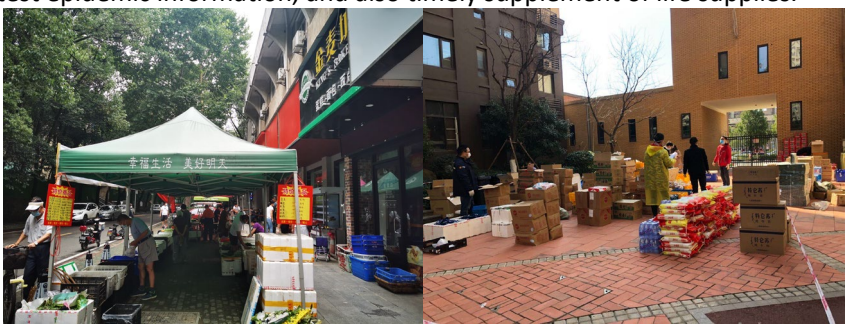


Figure 10 Community residents shopping during the outbreak

5.3. Community level: Building community mobilization and joint control mechanisms

When dealing with sudden disasters, the unclear rights and responsibilities of various groups are a big problem that hinders the progress of work. In response, the widespread organization of volunteers is a common practice, but this system is not long-term, so the current life circle needs an emergency response system to support. The main body of community management should actively adjust the participation of society, market, especially community unit level (Zheng et al., 2008, Yang, 2008). The needs and problems of residents are analyzed and defined based on the problems arising from public health events. In response to major public health emergencies, community leaders take the lead in providing direct services and drive volunteers to provide services. Forming a set of efficient community organization forms to enhance the thinking and action of community residents, and enhancing the ability to switch to emergency organization. This is also conducive to the formation of a complete set of joint prevention and control mechanism, and facilitate the formation of effective docking with the leadership of the administrative district office. The specific measures are shown in the table below(table2).

Table 2 Construction of a detailed community emergency response system

Classification of community residents	Content of emergency response	Level of participation
Community neighborhood committee, social organization	Community leadership mechanisms, community organizing functions, community support and training	Participation in community decision-making
Volunteers /Residents who support community work	Establish various types of community social organizations, strengthen internal unity, excavate and train the backbone of community residents.	Provide community services and assist in community work
Ordinary resident	Build residents' confidence in participation and raise their concern about community issues	To bring forward an opinion

Silent and unresponsive residents	Provide education	services,	community	Accept service

6. Conclusion

The exploration of human beings for a better living environment is advancing in constant practice, and the construction model of mechanism of public service emergency has achieved initial results. However, the research and practice on how to improve public service emergency are still in the blank area. In fact, the public service system itself is a part of the urban system, and there are also many ideas and resources to be explored. The mechanism of public service emergency proposed in this paper has certain practical possibilities. At the implementation level, different cities have different population density, traffic and economic levels, which have a vital impact on human daily performance and health. Therefore, it is necessary to develop public service standards for cities in different regions according to local conditions. The construction of mechanism of public service emergency focuses on autonomy construction. Special attention should be paid to community governance, as a grass-roots management unit, residents work together to improve the level of public governance and maintain public order, which also helps to maximize the overall public interests of the city.

7. Acknowledgments

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