

# Meal-on-wheel Service Facility Location Strategy for Longhua District in Shenzhen based on GIS

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**Abstract:** With the development of Shenzhen, aging population with needs of Meal-on-Wheel (MOW) service is increasing as well, especially Longhua District. This paper analyses the characteristics of the aging population in Longhua District, and evaluates the accessibility and living quality of current meals service location by applying Geographic Information System (GIS). It finds that the meal service system struggles from low demands and quality, highly depends on government subsidies, lacks of participation from social enterprises, and diversity in service levels. Based on the analysis, proper location strategy is made, and proper MOW service locations are allocated by GIS to extend the coverage of MOW services and suggestions are made properly to promote the improvement of the quality of catering services.

**Keywords:** Meal-on-Wheel; Facility Location Strategy; GIS.

## 1. Introduction

By around 2035, the number of elderly people aged 60 and above will increase to 400 million, and their proportion of the total population will exceed 30%, meaning that China will enter a heavily aging society. As a young city, Shenzhen cannot avoid the trend of population aging. The demand for senior care services is also growing, and the problems due to aging population stand out. The State Council issued the "14th Five-Year Plan" on February 21, 2022, which explicitly proposes to build an urban and rural meal-on-wheel service system, establish a network for meal service delivery, and support high-quality and diversified meals. Meal-on-wheel service facilities have been constructed all over the country and actively innovative meal service models have been exploring to realize the comprehensive coverage of meal-on-wheel service. As of February 2024, Shenzhen's meal-on-wheel service facilities reached more than 200, of which Longhua District is updated from time to time, and the number of facilities is at a medium to high level in the city. Longhua District has a relatively dense elderly population, which is typical. Therefore, the article focuses on exploring and analyzing the facility allocation strategy in Longhua, Shenzhen, to optimize the locations of the facilities and improve the coverage of meal services combing the current situation and data analysis, with aims to better meeting the meal needs of the elderly.

Gong et al. (2021) concluded that the health status of the elderly is closely related to their diets, and that they need to adjust their poor eating habits and control their nutritional intake in order to prevent diseases. Therefore, catering services should provide a variety of dining options to meet the taste preferences and nutritional needs of different elderly groups. Winterton et al. (2013) defined meal-on-wheel as a special food-delivery service that provides nutrition, food security, and social contact for older adults who cannot prepare their own food or are afraid, unwilling, or unable to order meals using apps. B. Wang et al. (2019) conducted in-depth research on a community meal-on-wheel program in G-city and found that the community meal-on-wheel program has problems such as unprofessional operation mode, ambiguous roles of the executing subjects, insufficient

funding, and unsustainability, etc. They put forward the idea of lean governance, which emphasizes inter-subjective synergistic governance, resource sharing, and big data supervision in order to achieve the precise provision of meal-on-wheel for the elderly and to enhance the efficiency of the service and its sustainable development. Deng et al. (2021) used DEA to analyze the service efficiency of 73 assisted living organizations in Beijing, and further explored the impact of factors such as the mode of assisted living, the attributes of the organization, and geographic differences on the efficiency of the service. Mellow et al. (2024) combed the food, nutrition, and dining practices of Australian nursing homes through a national survey, which helped to identify the key objectives of the intervention to improve the food, nutrition and quality of life of aged care residents. There is a relative lack of research on the coverage of meal service facilities and the analysis of site selection strategies, especially the analysis of site selection of meal service facilities based on the data of demographic characteristics and residential distribution, the distribution of public transportation, catering outlets, and neighborhood councils and other supply factors.

Meals-on-Wheel services have a certain degree of public welfare, and elderly meals-on-Wheel facilities are public facilities, and related research has attracted much attention from scholars at home and abroad (Lin et al., 2017; Lin et al., 2018; Lin et al., 2022). Lin et al. (2017) formulated the meal-on-wheel service districting problem as an integrated mixed-integer programming (MIP) model with aims at finding the minimum number of districts to cover all basic units while satisfying the constraints, including capacity and time window limitation, accessibility, compactness, and the indivisibility of locations. They found that the performance is significantly affected by the available time period for the service delivery, the capacity of a meal cart, and the maximum travel duration between any two basic units in a district. Lin et al. (2022) proposed simplified novel multi-objective mixed-integer linear programming models combined with a hierarchical clustering algorithm for the MOW delivery problem which considers the value of Physical Internet (PI) and three different delivery models--self-delivery (SD) model, outsourcing-delivery (OD) and volunteer-delivery (VD)

models. They claimed that the VD model exhibited strong adaptability to PI. The OD model is more sensitive to the marginal traveling cost, the VD model is more sensitive to the fixed dispatching cost, and both the SD and VD models are sensitive to the geographical demand distribution and number of clusters. PI in the VD model improves meal quality in almost all situations. This study can guide IHC centers on the adoption of PI and MOW models. Borba et al. (2022) proposed a geographic information system (GIS) that links the spatial distribution of police occurrences, budget constraints, and maximum coverage distances in support of analyzing and recommending the location of potential police facilities. The system uses k-means for cluster analysis and candidate location definition, and uses the maximum coverage location problem to optimize predefined locations to support police facility location decisions and help improve public safety services. X. Wang et al. (2021) used POI data, population data from the Sixth Population Survey, and existing data on the distribution of elderly facilities in the city as inputs, and applied machine learning algorithms to quantitatively simulate the location layout of elderly facilities, so as to optimize the results of the location of elderly facilities in Wuhan, while avoiding the subjectivity in the planning of the selection of the location. Huang et al. (2023) used Gaussian two-step moving search method to evaluate the matching degree between the service capacity of assisted living facilities and the demand of the elderly population in Shanghai. GIS, machine learning algorithms, and the mobile search method have been used to optimize and evaluate the siting of public facilities, giving the article a lot of inspiration for the study of siting strategies and optimization of meal-on-wheel service facilities in Longhua District, Shenzhen.

Geographic Information System (GIS) siting model is an analytical method used to determine the best location or area. This model combines geographic data and spatial analysis techniques and has applications in a variety of fields, including business, environmental planning, and infrastructure development. By utilizing geographic information and spatial analysis techniques, the model can help decision makers make more accurate and scientific siting decisions, improve resource utilization efficiency, and reduce risks and costs. He et al. (2023) used the GIS network analysis method to rationally divide the firefighting units and create the firefighting road network and fire station model with the guidance of protection objectives and fire problems, which scientifically and objectively improves the coverage of

firefighting services and provides an important reference for the optimization of the overall layout and structure of the urban firefighting station. Salimi et al. (2021) utilized the analytic functions in GIS to propose a novel approach for sports site selection. By transforming the research database into hierarchical data in a GIS environment, the method of minimizing the standard deviation difference of polygons was used to minimize the high-value areas in the siting maps, thus realizing the successive planning of multiple sports venues. Saeidian et al. (2018) used a combination of GIS techniques, cluster analysis and TOPSIS multi-criteria comprehensive evaluation method to effectively solve the temporary rescue center's optimal layout challenges.

The article will use the GIS network analysis method to cut in, combining POI data, population characteristics, residential distribution, distribution of meal-on-wheel service facilities, public transportation and distribution of food and beverage outlets, etc., to analyze the siting strategy of meal-on-wheel service facilities and optimize the siting plan of facilities in Longhua District, Shenzhen City, so as to improve the due value of meal-on-wheel service facilities.

The remainder of this paper is organized as follows. In section 2, an over analysis of meal-on-wheel service in Shenzhen is conducted. In section 3, detail analysis on the demand and supply of meal-on-wheel service and meal-on-wheel facility location in Longhua District is constructed. Section 4 concludes with a summary and recommendations for future research.

## 2. Meal-on-Wheel Service in Shenzhen

### 2.1. Distribution of Elderly Population and Meals-on-Wheel Facilities

As shown in Table 1, the 2020 census yearbook data of Shenzhen shows that the degree of population ageing varies among the 10 districts in the city. The total number of people aged 60 and above in Shenzhen is 931,827, accounting for 5.33% of the total population. Longgang District has the largest number of elderly people, reaching 208,777. It is followed by Bao'an District, Futian District and Nanshan District, with 171,629, 130,961 and 129,780 people respectively. The aging rate of five districts exceeds 7%, with Luohu District having the highest degree of aging and Guangming District the lowest. Longhua District is close to 5 percent.

**Table 1.** Distribution of aging population in each district of Shenzhen

Administrative district	Total population	Number of elderly people aged above 60 years	Ageing rate
Luohu	1143801	97993	8.57%
Futian	1553225	130961	8.43%
Nanshan	1795826	129780	7.23%
Bao'an	4476554	171629	3.83%
Longgang	3979037	208777	5.25%
Yantian	214225	16268	7.59%
Longhua	2528872	103414	4.09%
Pingshan	551333	24469	4.44%
Guangming	1095289	37602	3.43%
Dapeng	156236	10934	7.00%
Total	17494398	931827	5.33%

At the beginning of 2024, the government website of the Shenzhen Civil Affairs Bureau announced 257 meal-on-wheel service facilities, which were divided into four categories: meal centers, day-care canteens, collective canteens of aged-care institutions, and canteens for the elderly, of which there were 182 and 50 meal centers and canteens for the elderly, respectively, which accounted for the majority of the total number of meal-on-wheel service facilities. The number of meal-on-wheel service facilities varies from

district to district, with Nanshan District, Bao'an District, Futian District, Longhua District and Longgang District having more than 30 meal-on-wheel service facilities, of which Nanshan District has 51, the largest number of meal-on-wheel service facilities; and Dapeng New District, Luohu District, Yantian District, Guangming District and Pingshan District having fewer than 20 meal-on-wheel service facilities, with Pingshan District having the fewest with only six facilities.

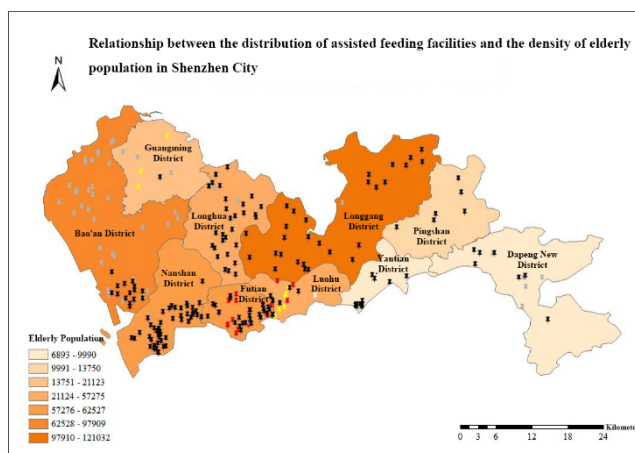


Figure 1. Distribution of meal-on-wheel service facilities and elderly population in Shenzhen

Figure 1 illustrates the distribution of meal-on-wheel service facilities and the density of the elderly population in Shenzhen. The five colored pin marks represent the five types of meal-on-wheel service facilities - black for meal-on-wheel stations, grey for elderly canteens, red for elderly institution-type canteens, yellow for day-care type canteens, and white for social catering type canteens. Nanshan District, Bao'an District and Futian District are areas in Shenzhen with a high density of elderly people and relatively more meal-on-wheel service facilities. Yantian, Pingshan and Dapeng New Districts have fewer meal-on-wheel service facilities, which is related to the lower density of elderly population. Guangming District has a larger elderly population but fewer meal-on-wheel service facilities.

## 2.2. Accessibility of Meal-on-wheel Service Facilities

The article defines a 15-minute walking circle to analyse the accessibility of meal-on-wheel service facilities for the elderly in Shenzhen. Because walking is the ideal transportation mode for the elderly, and its accessibility level directly reflects the accessibility of meal-on-wheel service facilities, it has a certain reference value. Firstly, the latitude and longitude data of meal-on-wheel service facilities in each district were obtained by Tencent Map API. Secondly, based on the vector data of road network of Shenzhen obtained by OpenStreetMap, the network data set is collected. Import the latitude and longitude data of the meal-on-wheel service facilities, and create the service area through the network analysis function of GIS. Set the impedance to the actual length of the road, and interrupt it after the default distance exceeds 1,000 meters to generate the service area map of the meal-on-wheel facilities in each district. The results with the help of GIS network analysis technique is shown in Figure 2, which shows the low coverage of the meal-on-wheel service facilities.

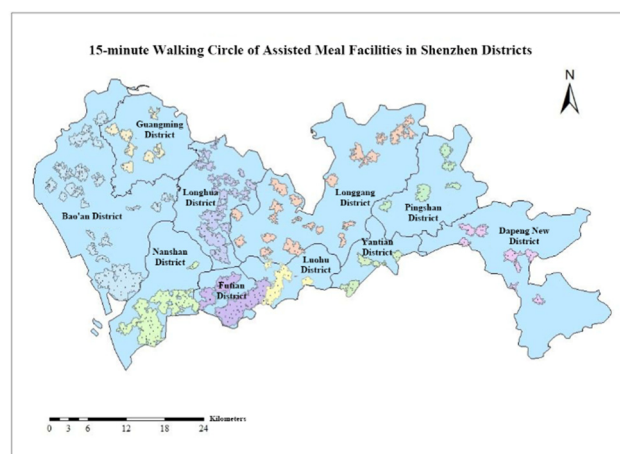


Figure 2. 15-minute walking circle of meal-on-wheel service facilities in each district of Shenzhen

From Figure 2, it can be seen that Futian District, as the city center, has the highest coverage rate of meal-on-wheel service facilities, reaching 51.44%; Guangming District, Longgang District, Yantian District, Pingshan District, Dapeng New District and other meal-on-wheel coverage rate of about 10%; Luohu District, Nanshan District, Bao'an District, Longhua District, with the coverage rate of 20% up and down, in addition to Futian District, the other districts still have a greater room for progress.

Comparing the number of meal-help facilities and the number of elderly population in each district, it can be found that Longhua District has a higher number of meal-on-wheel service facilities, while the number of elderly population is at a medium level, which indicates that Longhua District may have a more comprehensive community construction and development plan, including the planning and construction of service facilities for the elderly, and that the community residents may have a higher degree of awareness and

participation in services for the elderly, and that there may be more volunteers or organizations that are willing to participate in the meal-on-wheel service, thus enabling the good development of the meal-on-wheel service. Therefore, the article focuses on Longhua District and analyses the strategy and optimization of the location of meal-on-wheel service facilities.

### 3. Meal-on-wheel Service in Longhua

#### 3.1. Meal-on-Wheel Demand

The population distribution of the streets in Longhua District is shown in Figure 3-4. Minzhi Street has the largest elderly population, up to 36,260, accounting for 5.88 percent, Longhua Street is the second largest, Dalang Street and Fucheng Street do not have a large difference in the elderly population, and Guanlan Street has the smallest number of elderly people, only 7,379. Fucheng Street has the lowest elderly population, accounting for 3.05 percent.

Apart from age, which will affect the demand for meal-on-wheel services, the living conditions of the elderly are also one of the important factors influencing demand. As they age, some elderly people's ability to take care of themselves declines, making it difficult for them to prepare meals on their

own. At the same time, elderly people, especially those aged 80 and above, face greater safety and health risks when they live alone. For example, they are unable to detect food safety hazards in time or ensure that their diet is nutritionally balanced. As a result, they need outside help to obtain healthy and nutritious meals. In addition, elderly people living alone usually lack family or social support networks and are unable to receive timely care and assistance. Under such circumstances, community meal-assisted services should not only provide meals, but also help them reduce loneliness and social isolation. It is more urgent to address the need for meal-on-wheel for the elderly living alone. Figure 5 shows the distribution of the number of households in which elderly people live alone, elderly couples live together, and elderly and young people live together in each street in Longhua District. As can be seen from Figure 5, the number of households with only elderly people living in each street in Longhua District is above 1400, with the highest number reaching 3781. Among them, the number of households with elderly people living alone is no less than 950 in each street. This means that there is a large group of elderly people in Longhua District who need the support of community-based meal-on-wheel services.

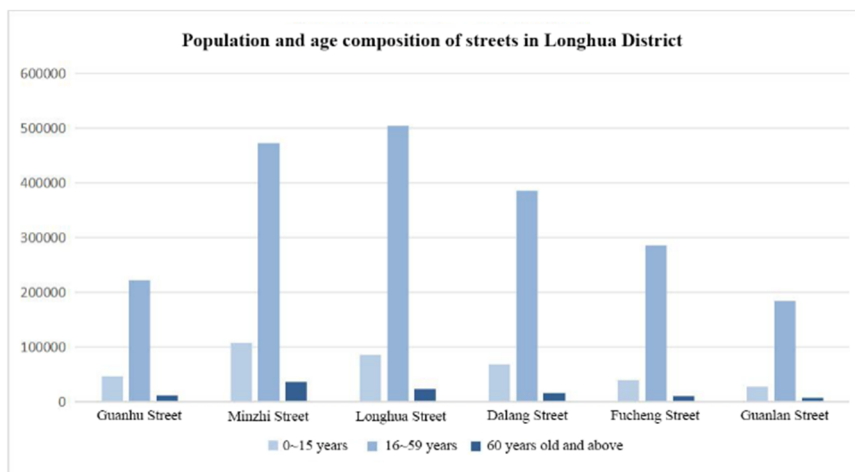


Figure 3. Population Distribution by Street in Longhua District

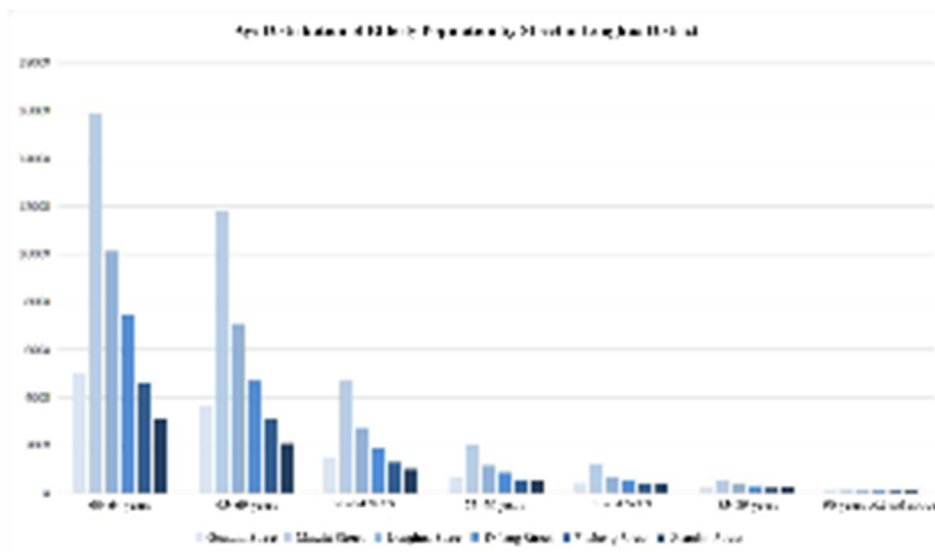


Figure 4. Aging Population Distribution by Street in Longhua District

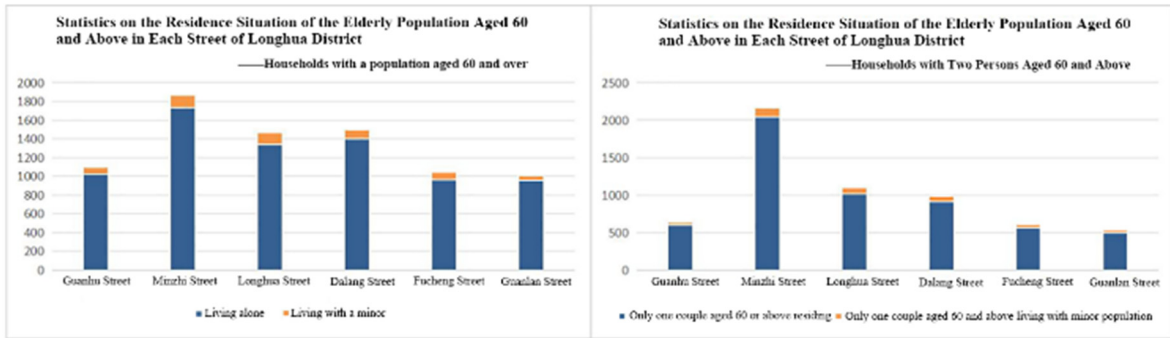


Figure 5. Distribution of Residential Situation of the Elderly Population by Street in Longhua District

In addition to age and living conditions, the health level and self-care ability of the elderly are also key factors affecting their demand for meal-on-wheel. According to the Yearbook of Shenzhen 2020 Population Census, in Longhua District, a total of 1,961 elderly people is in 'basic health' (meaning that they are in a reasonable state of health and have the ability to take care of themselves in their daily lives); 242 elderly people are in poor health but are able to take care of themselves independently; and 100 elderly people are unable to take care of themselves. Regardless of the level of health status, maintaining a balanced nutritional profile among older adults is of paramount importance, and is key to increasing resistance and maintaining intrinsic capacity and physical functioning. Zhu et al. (2024) suggest that interventions that include an assessment of existing dietary diversity, a variety of dietary supplements for daily living, and maintenance of nutrient digestive and absorptive capacity in advanced age may be beneficial in ensuring that dietary diversity has an impact on the health status of older adults, particularly in terms of maintaining intrinsic capacity. impact, particularly in terms of maintaining intrinsic capacity and physical functioning. The high prevalence of hypertension, diabetes mellitus and hyperlipidemia are closely related to poor dietary habits and inappropriate food combinations. Especially for the elderly population, it is more important to choose light-flavored and nutritious meals. A study by Zou et al. (2023) on the dietary preferences of older people attending assisted living facilities found that, despite differences in the number of days per week or the frequency of meals served per day in some assisted living facilities, the majority of older people still chose an assisted living facility close to their homes on a relatively regular basis. The proportion of food purchased from these facilities with different opening hours and meal frequencies exceeded 38.00 per cent of the total food intake in a day, which is strong evidence that meal-on-wheel services play a key role in ensuring the daily nutritional needs of the elderly. In addition, some of the field surveys found that most of the elderly people would dine at the assisted feeding facilities near their homes because of the variety of food items and flavors provided by the facilities. All in all, the elderly have a high degree of reliance on assisted feeding facilities.

### 3.2. Meal-on-wheel Service Supply

As shown in Figure 6 (left), the distribution trend of elderly assisted meal supply stations and the density of elderly groups in Longhua District is basically not in line with each other: the number of elderly population gradually increases from north to south; except for Guanlan and Dalang Streets, which

have special circumstances, the number of assisted meal facilities in the other four streets is between 6 and 8, with little difference. Figure 6 (right) shows the coverage of assisted feeding facilities in each street. The coverage rate of residential areas in Fucheng, Guanhu, Longhua and Minzhi Streets is basically between 50% and 70%. On the other hand, Guanlan Street and Dalang Street both have only one Meals-on-Wheel facility with a relatively remote location, and their coverage rates are both less than 1%. On the whole, Longhua District's meal-on-wheel service is in its infancy, and the distribution of service provision is uneven.

Specifically, of the 31 meal-on-wheel facilities in Longhua District, two of them are elderly care institutions under the Hau Tak Family, and their service targets are mainly elderly people living in the institutions. There is also one publicly-funded and privately-funded meal-on-wheel facility which has not yet commenced operation. The remaining 28 facilities can be broadly classified into the following three categories:

Meal collection stations, which are located in party service centres or community centres. These sites have limited space and there is no extra space for setting up specialized elderly dining facilities.

There is no extra space for setting up a special dining area for the elderly. Meal distribution is contracted by the Houde Shijia, which delivers the meals to the party centres and neighborhood committees, where older persons who have ordered meals in advance pick them up on their own. There are 15 such facilities, of which four are not yet in operation. Most of the pick-up stations in operation have a daily order volume of between 10 and 15 meals, while the daily order volume of the Shanghefang Party and Community Service Centre in the Mintai Community can reach 30 meals.

Elderly service stations are mostly located in residential areas. There is a total of seven, four of which are located in residential neighbourhoods, and three of which are Starlight Homes for the Elderly. The service stations in residential areas also do not have any dining space, but they provide meal delivery service with an order quantity of between 10 and 15 meals. The Starlight Homes for the Elderly have enough space, but the number of orders is almost zero. the Starlight Homes for the Elderly, in addition to assisted meals, also include a reading room, sports and fitness, board games, elderly education programs, singing and dancing rehearsals, and other functions.

Catering enterprises provide assisted meals. There are a total of six canteens, namely Laoxiang Chicken, four Zhenkongfu canteen and Hung Luck Dangtou Food City. Laoxiang Chicken serves around 20 meals per day,

Zhenkongfu serves between 20 and 30 meals per day, and Hung Luck Dangtou Food City serves around 30 meals per day, with a peak of 60 meals per day. The Food Court has a

number of stalls offering a wide variety of dishes for all three meals, with a total dining area of 980 square meters.

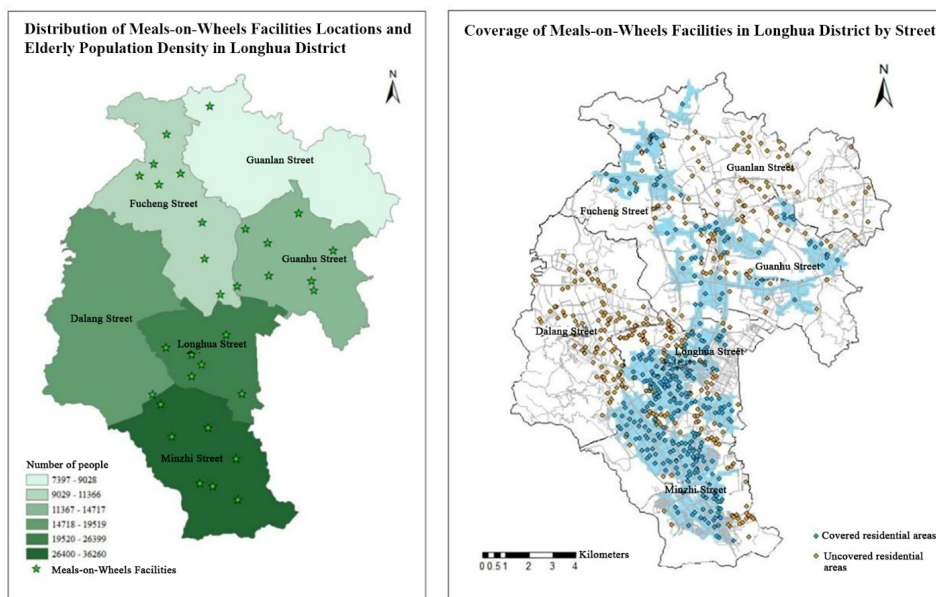


Figure 6. Meal-on-wheel service facility in Longhua District by Street

Most of the above-mentioned meal-on-wheel service facilities do not have a strong service capacity, their resource utilization rate is unsatisfactory, and some of them are even virtually non-existent. The service situation of the meal service stations of catering enterprises with strong operational capability is only slightly better than that of other types of meal service facilities. The various situations illustrate the following: inaccurate statistical information on meal-on-wheel service services and delayed commencement of meal-on-wheel service services for the elderly. Elderly people living in the vicinity of assisted living facilities are not aware of the existence of assisted living services for the elderly, and publicity efforts have not been effective.

### 3.3. Summary of Meal-on-wheel Service

Based on the analysis on demand and supply of meal-on-wheel service in Longhua District, some issues stand out. First, the ratio of the area where the meal-on-wheel service facilities are located should be closely positive-related to the ratio of the population, but according to the data, the number of meal-on-wheel service facilities in the district is on the low side, the coverage rate is on the low side, and the mismatch between supply and demand is still a prominent problem. Second, the main sources of income for organizations providing meal-on-wheel service are government subsidies and sales revenue. Some elderly canteens also have charitable funds, corporate donations, and corporate investment. Most of them only break even. Without the participation of social forces, the sustainability of these facilities is low. Third, the participation rate of social forces is low. The government's participation has increased, but the participation of catering enterprises, NPO, and volunteers is low. Finally, wide variation in service levels exist.

## 4. Meal-on-wheel Service Facility Location Strategy

### 4.1. Meal-on-wheel Service Cooperation Modes

There are three main modes of meal-on-wheel cooperation in Longhua District:

Cooperation between community neighborhood committees and meal suppliers: Under the organization of community neighborhood committees, some local catering enterprises have responded positively to the call for cooperation with the community to set up meal stations for the elderly in the community. The mode of cooperation is that the meal suppliers will provide the meals, while the community committee will provide management services, and some of them will provide dining venues. For example, the Luhu Community Meal-on-Wheel Station in Guanhu Street cooperates with the elderly care organization Houde Shijia, where the community workstation is responsible for publicizing the meal help service for the elderly and acting as an intermediary to help elderly people in the community to submit applications for meal help, while Houde Shijia is responsible for the production and distribution of the meals.

Self-built by Community Resident Committees (CRCs): In some communities, CRCs are directly responsible for the construction of elderly canteens or subsidized meal stations, which may be located in unused space within the community or inside specific buildings. The community neighborhood committee may carry out the construction and equipment procurement through government grants or other resources, and then cooperate with relevant food service organizations to provide elderly dining services. For example, the Lingzhiyuan Community in Xin'an Street joined hands with the elderly service organization Yi Centennial to set up the Lingzhiyuan Community Elderly Dining Hall. Due to space constraints, the canteen operates both online and offline, with volunteers from the "Lok Sin Kiosk" next to the canteen being responsible for delivering meals.

Cooperation between the government and catering brands: Under the advocacy of the Shenzhen Municipal Government, in order to facilitate the elderly to dine nearby, some well-known catering chains have signed cooperation agreements with the government to set up elderly meal helpers in designated areas. Currently, famous brands such as Zenkungfu, Noodle King, Yonghe Daiwang, Red Lychee Village, Laoxiang Chicken and Yuanji Cloud Dumpling are joining the queue of elderly meal helpers one after another. The cooperation model introduces the "Internet + intelligent meal-on-wheel" technology, meal needs of the elderly can apply for meal-on-wheel in the "i Shenzhen" software elderly module, information registration is successful before going to the meal-on-wheel stations, with the help of face recognition technology to verify the information, the system can accurately recognize the identity of the elderly, the system can accurately recognize the identity of the elderly.

The participation of community neighborhood committees in the operation of assisted-meal facilities can realize the integration of social resources, promote the efficient use of public service resources and enhance the level of community services. Such cooperation not only facilitates the enjoyment of dining services by older persons in their immediate vicinity, reduces the cost and inconvenience of travel for older persons and improves the convenience and accessibility of meals, but also promotes exchanges among older persons, enhances neighborhood relations, strengthens community cohesion and a sense of belonging, and creates a warm and harmonious community atmosphere, thus reflecting society's care for and respect of older persons and enhancing their sense of social participation and self-esteem.

The model of cooperating with well-known restaurant chain brands has the advantage of quick implementation and efficient operation. Catering brands usually have high visibility and good brand reputation, and they have unified and standardized business models and service processes,

which can ensure the stability and reliability of food quality and service quality. This can increase the trust of the elderly in the catering service and meet the needs of the elderly group for nutrition, taste and food safety. Cooperation with well-known chain restaurant brands can be a good solution to the problem of "overcrowding in small facilities and waste in large ones". Firstly, most of the restaurant brands have sufficient area, and secondly, they are usually able to realize raw material procurement, cost control and efficiency enhancement through the effect of scale, so as to provide catering products at relatively stable prices, and they can also provide food and beverage products at relatively stable prices under the mature operation model. It is less difficult for them to incorporate elderly meal-on-wheel services under their mature operation model.

## 4.2. Convenience Assessment and Facility Location Strategies for Various Streets

Because of their physical condition and age and other mobility limitations, walking, taking public transportation or the subway are more suitable modes of travel for the elderly. Meals-on-Wheel facilities located along bus routes or near the exits of subway stations can make it easier for older persons to use public transportation or walk to meals. Therefore, it is crucial to locate assisted living facilities in convenient locations. As shown in Figure 7 (left), most of the meal-on-wheel facilities are located near transportation stations. Most of the public transportation stations are clustered in four streets, Fucheng, Dalang, Longhua and Minzhi, which have better accessibility and therefore have more meal-on-wheel facilities. On the other hand, Guanlan and Guanhu streets have fewer public transportation stations and their distribution is relatively dispersed, making them less accessible.

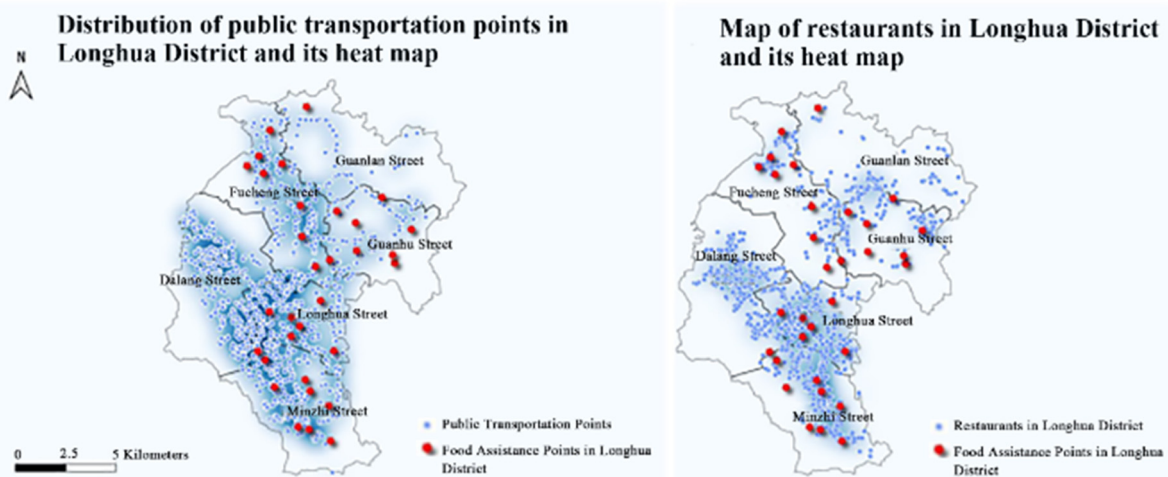


Figure 7. Distribution of public transportation and food and beverage outlets in Longhua District

As can be seen in Figure 7 (right), the lower number of food and beverage outlets owned by the three streets of Guanlan, Fucheng and Guanhu is related to the lower population density of these three streets. In addition, these food and beverage outlets are basically concentrated near the demarcation lines of the three streets, indicating that opening food and beverage outlets near the demarcation lines where more people gather is conducive to obtaining more customers. In conjunction with the transportation and amenity

assessments, different facility location strategies should be used for each street:

**Fucheng Street:** This street has good accessibility, so the main mode of service is dine-in. However, the number of food establishments in the area is low, so priority was given to the establishment of meal-on-wheel facilities around the neighborhood association when selecting sites.

**Guanlan and Guanhu Streets:** The accessibility of these two streets is poor, so the main mode of service is to deliver meals

to households in order to cover a larger service area. The number of food establishments distributed in these two areas is also relatively small, so priority is still given to setting up meal-on-wheel service facilities around the Resident Committees when selecting sites.

Dalang, Longhua and Minzhi streets: these three streets have good transportation accessibility, so the main service mode is dine-in. These streets have a large number of catering outlets, but the number of well-known catering companies currently in existence is difficult to meet most of the demand for meal-on-wheel. Therefore, priority is given to cooperation with catering enterprises, while residential areas that cannot be covered are taken over by neighborhood committees.

### 4.3. Meal-on-wheel Service Facility Location based on GIS Network Analysis

The network analysis method better realizes the integration of travel paths and roads, and the analysis using vector road data can be recognized as a buffer analysis method based on the real road network and real spatial resistance, which has the advantage of overcoming the error that the buffer analysis method cannot identify the obstruction in the road. The network analysis method requires high data acquisition, and its analysis results are more objective and accurate and scientific. Therefore, this paper adopts the network analysis method to carry out the siting research of food aid facilities.

The construction of the site selection model for assisted living facilities requires point elements, line elements and the number of elderly population in each residential area in

Longhua District. Point elements: including facility stations (alternative stations for assisted feeding facilities) and request stations (geometric centers of residential districts), which are derived from the Gaode Map Open Platform API. line elements: derived from the OpenStreetMap open-source map of Shenzhen Longhua District's Road network data, which include elevated and expressways, urban main roads, urban secondary roads, pedestrian roads and internal roads, etc. Since the model is built based on the elderly traveling to assisted feeding facilities by walk to the assisted feeding facilities, so only roads that support pedestrian use are extracted. The extracted roads were merged and interrupted and topology checked to construct the network dataset. The number of elderly people with Shenzhen household registration in each residential area in Hua District: the number of households in each residential area was crawled by the software and then estimated according to the ratio of the number of elderly people to the number of households in each street. The process of population estimation is as follows: calculate the average number of elderly people living in each household in each street based on the total number of elderly people and the total number of households in each street, then estimate the number of resident elderly people in each residential area by multiplying the number of households in each residential area by the average number of elderly people living in each household, and finally estimate the corresponding number of elderly people with a Shenzhen household registration based on the ratio of the Shenzhen household registration population.

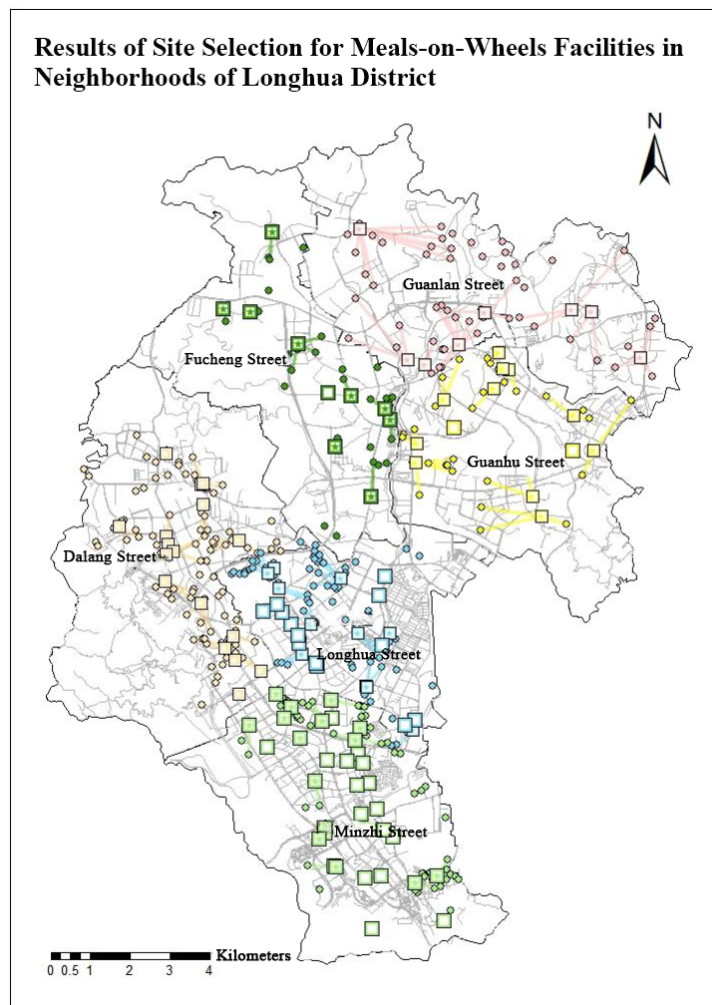


Figure 8. Meal-on-wheel facilities by streets in Longhua District

Using the network analysis tool of GIS to create new location assignments, the location data of the restaurant alternatives, the neighborhood committee alternatives, and the 332 residential areas that have not yet been covered are divided according to the corresponding streets and loaded into the respective models. When importing the residential area data, the weighting factor was set to the number of elderly household members. The problem type was set to "Maximize coverage with capacity constraints". The impedance interruption is set to "3000 meters" and the default capacity is set to "300" for the streets with the service mode of home delivery, and "1000 meters" and the default capacity is set to "300" for the streets with the service mode of dine-in. For streets with a dine-in service mode, the impedance interruption is set to "1000 meters" and the default capacity is set to "200".

After modeling and solving, the results of site selection are obtained as shown in Figure 8. According to the order of Guanlan, Fucheng, Guanhu, Dalang, Longhua and Minzhi, the number of new assisted feeding facilities is 9, 9, 12, 14, 11 and 15, and the coverage rate of the residential area increases to 81%, 82%, 98%, 66%, 86% and 90% in that order. The coverage rate of meal-on-wheel services in Guanhu Street is close to 100%, which is basically in line with the requirement of "full coverage of the meal-on-wheel service system for the elderly" proposed in the relevant policy. The coverage rate of meal-on-wheel services in Dalang Street is not satisfactory. Subsequently, consideration can be given to expanding the service scope of each meal-on-wheel facility, that is, to include home delivery of meals as one of the major service modes. The remaining four streets are mainly constrained by the scale of service, but if the number of meals provided daily increases, their service coverage rate can be improved.

#### 4.4. Suggestions for Meal-on-wheel Service Facility

It is worth to note that the coverage rate does not mean everything. At present, Shenzhen's assessment criteria for meal-on-wheel service facilities are satisfied, it mainly focuses on the quality of the meal service. Combined with the current requirements for the construction of the meal-on-wheel service system, there are three very important criteria, namely, the coverage rate, the service quality, and sustainability. With the increase in the number of service facilities, the government's financial pressure will increase, and an important means to improve service quality and sustainability while keep high coverage rate is the introduction of social capital to participate in the meal-on-wheel service supply.

There are a number of different service models for enterprises to participate in meal-on-wheel services for the elderly, which can be categorized into enterprise-community cooperation, enterprise-government cooperation, enterprise-healthcare institution cooperation, and enterprise-enterprise cooperation.

When enterprises cooperate with the community, the partners include community activity centres, senior citizens' associations or other NGOs. This kind of cooperation usually focuses more on community participation and the use of volunteers, which can enhance the community roots and sustainability of the project. This kind of model is also the one that has been most frequently used in China.

When enterprises cooperate with the local government, the enterprises can make use of the government's resources and channels to provide catering services. In this model, the government may provide financial support, venues or publicity resources, while the enterprise is responsible for the daily operation and quality of the catering service. For example, the Elderly Dining Hall of Noodle King in Meilin Yicun, Futian District, innovatively launched a government-enterprise co-operation in elderly meal assistance service.

When enterprises co-operate with healthcare organizations, including hospitals, nursing homes or other healthcare organizations, the model can provide meals suitable for the health conditions of the elderly and ensure that the catering service better meets their health needs.

When enterprises co-operate with enterprises, including professional catering companies, food suppliers, food transporters and other enterprises, the quality and efficiency of the catering service can be improved. This kind of cooperation usually focuses on economic benefits and also enhances the professionalism of the service.

Each model of co-operation has its own strengths and challenges, and social enterprises need to consider a number of factors such as their own resources, the needs of their target groups and sustainability when making their choices.

To keep meal-on-wheel service facilities running in high quality, some suggestions are provided.

(1) In terms of construction. Apart from the need to meet basic requirements, a pleasant social space should be designed to encourage interaction among the elderly. Chess rooms and reading rooms can be provided to enhance the community atmosphere. Where necessary, it should be equipped with basic medical emergency equipment or have strong links with nearby medical institutions. Staff need to be professionally trained to understand the needs of the elderly and have basic first aid and service skills. Service staff should be patient and caring.

(2) In terms of operation. The main need is to safeguard safety and quality. In terms of safety, first of all, in terms of food safety, improve the construction of the elderly meal service system, strict supervision of food material procurement, meal production process. Establish long-term cooperation with reliable suppliers to ensure the quality of food materials and stability of supply. Scientific storage methods need to be adopted to ensure that ingredients are not contaminated during storage and meal preparation. Food allergy information should be clearly labelled on the menu to ensure that the elderly are aware of the ingredients of the food they eat. Secondly, apart from food safety, information security also needs to be emphasized. Understand the basic health status of the elderly when receiving them so that emergency assistance can be provided when needed. For the personal information collected from the elderly, establish a secure information management system to ensure that the information is not leaked.

(3) In terms of service quality. Conduct regular satisfaction surveys of the elderly in operation, collect feedback, understand their needs and suggestions, and continuously optimize the service. Provide diversified menus, taking into account the tastes and eating habits of the elderly and avoiding homogenization. Besides, in terms of ageing-friendly services, the operator should base on the government's basic requirements, such as barrier-free access, easy-to-see signs, and elderly window settings. On this basis,

they should develop appropriate ageing services, such as personalized menus, specific resting places, emergency medical equipment, and so on. In short, with the government's requirements as the benchmark, the operator's service awareness is appropriately brought into play to improve the perfection of ageing-friendly services and to promote the process of standardization of elderly meal assistance services.

(4) In terms of partnerships sustainability. Establish close partnerships with other relevant organisations and enterprises to jointly promote the development of elderly meal assistance services. This includes cooperation with catering enterprises, social organisations and medical institutions. Establish a sound monitoring system to regularly assess the quality and effectiveness of the service. Through the feedback mechanism, timely adjustment and optimization of the service mode will be made to ensure that the service can meet the needs of the elderly. To formulate a long-term plan for assisted feeding services for the elderly, taking into account factors such as the trend of population ageing and socio-economic changes, so as to ensure the sustainability of the construction of the service system.

## 5. Conclusion and Future Works

As the trend of aging in Shenzhen City is becoming more and more apparent, the increase in elderly care services has posed new challenges to the supply of elderly care services. The State Council issued the "14th Five-Year Plan for the Development of the National Aging Career and Pension Service System" on February 21, 2022, which explicitly proposes to build an urban and rural elderly meal service system, establish a network of elderly meal service, and support high-quality and diversified meals in terms of strengthening the capacity of home-based community pension services. The article firstly analyzes the current situation of elderly meal service in each district of Shenzhen, and finds that the existing meal service facilities cannot meet the demand, and it is necessary to optimize the layout of meal service facilities in each district. Among them, Longhua District has typical characteristics, with a relatively dense distribution of the elderly population and a medium level of assisted feeding facilities. Therefore, the article focuses on exploring the location strategy of assisted feeding facilities in each street of Longhua District, Shenzhen. First, by analyzing the characteristics of the elderly population and the situation of the elderly living alone in Longhua District, it is inferred that the elderly in this area have a high degree of dependence on the Meals-on-Wheel for the Elderly (MOWE) facilities. The second step is to understand the service capacity and utilization of the 31 existing meal-on-wheel facilities in Longhua District by investigating the service attendance and dining area of the meal-on-wheel facilities. The results of the survey show that the meal-on-wheel system in Longhua District is not yet perfect, and many meal-on-wheel facilities have not realized their value. Subsequently, the article used GIS technology to assess the community facilities support situation and the quality of the living environment in Longhua District. It mainly analyzed the distribution of public transportation stations and food and beverage outlets in each street of Longhua District, and most of the public transportation stations and food and beverage outlets were clustered in the southern part of Longhua District, i.e., three streets, namely, Dalang, Longhua and Minzhi. Based on the results of this assessment, the priority areas for the location of meal service facilities were identified, and these areas were

used as alternative locations for meal service facilities. Based on the POI data of Gaode Map and the road network data of the OSM platform, the network analysis tool of GIS was used to establish a location allocation model of "maximizing the coverage with capacity constraints". The results show that after optimizing the location, the coverage rate of meal service in each street has been greatly improved. Some sustainability suggestions for running meal-on-wheel facilities are made from the perspectives of construction, operation, service quality provision, and relationship management.

The article also has shortcomings. The government's publicized list of meal-on-wheel service facilities is too voluminous and lacks the time and effort to conduct an actual survey to determine the number of facility sites that effectively provide meal-on-wheel service services to the elderly. The actual area served by meal-on-wheel service facilities in various administrative districts would be smaller than the findings of this article. In the future, more in-depth field research work is needed to ensure the accuracy of the information on meal-on-wheel service facilities and to provide more reliable data support for the planning of meal-on-wheel service services. In addition, more potential addresses available from the government should be collected for the site selection strategy and analysis of assisted feeding facilities, so as to build a spare pool of assisted feeding facilities, and to explore the coverage rate and resource utilization rate of assisted feeding services under different site selection strategies in combination with the real operating rules. Based on the existing data, the article analyzes the site selection of meal service facilities, and in the future, it can deeply explore the sustainable development strategy of meal service facilities.

## Data Availability Statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

## Author Contributions

Meiyan Lin: Conceptualization, Investigation, Validation, Writing - review & editing.

Weizhi Tong: Investigation, Validation, Writing - review & editing.

Jingyuan Li & Caixuan Guo & Anqi Liu: Conceptualization, Methodology, Model setup and analysis, Writing - Original Draft, Writing - review & editing.

Ting Wang: Validation, Writing - review & editing.

## Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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