Two-Step Floating Catchment Area Method

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Contributor: Linggui Liu, Han Lyu, Yi Zhao, Dian Zhou

With the continuous aging of society, the demand among elderly citizens for care facilities is increasing. The accessibility of elderly care facilities is a significant indicator for evaluating whether the layout of urban elderly care facilities is reasonable, and research on the spatial accessibility of related facilities has become an important academic issue.

Keywords: aging ; elderly care facilities ; accessibility ; ArcGis

1. Introduction

Prominent population growth in urban cities and the aging of society are two trends in cities worldwide, especially those in developing countries [1]. To some degree, population aging is a sign of progress in social development, but it also puts great pressure on social pensions. Nowadays, the aging of the population is a common concern of the international community. The global proportion of the population aged 65 and older rose from 5% in 1960 to 9% in 2018 and is expected to rise to 16% by 2050, when nearly 80% of the elderly population will be living in developing countries [2]. The rapid growth of the elderly population has become a prominent and global phenomenon, including in developed countries such as Canada [3] and Japan [4] and developing countries such as Thailand. Since the 21st century, the aging process in China has accelerated significantly and the problem of elderly care has become increasingly prominent. With the increase in aging and the burden of family retirement, there is a growing demand for elderly care facilities. According to the data of the seventh population census [5], the fertility rate of China's population continues to decline, the proportion of the elderly population continues to rise, and the age which people reach is increasing. Compared with developed countries, China's aging population is characterized by a large scale, rapid growth rate, and aging beyond their wealth.

Spatial accessibility is an important reference indicator to determine whether the layout of various facilities is reasonable. Lee and Kim pointed out that the reasonable layout of public health facilities is crucial to their service quality and satisfaction, and is one of the basic needs of residents [6]. Therefore, it is vital to analyze the accessibility of elderly care facilities for elderly residents in different communities. In addition, since the demand for elderly care facilities varies in space and time [7], understanding the variation in demand can help decision makers to better arrange the geographical distribution of facilities and the related service hours. Therefore, scientific accessibility analysis is the basis for judging the variability of regional elderly services and optimizing the spatial allocation of resources. Spatial accessibility includes three basic elements: population, service supply level, and distance. The two most commonly used models for accessibility evaluation are the potential model and the two-step floating catchment area method (2SFCA) model. Xi'an is an important city in the development of Western China. At present, under the active guidance of national policies, elderly care facilities are developing rapidly in terms of quantity and quality, but the problem of an unbalanced supply–demand structure is still prominent. Therefore, the application of scientific methods to evaluate the spatial accessibility of Xi'an elderly care facilities can help researchers to better understand the layout of elderly care facilities and alleviate the problems brought by the aging society. According to Sunwei Liu [8], the results of a comparison of the 2SFCA and other potential models to evaluate community facility accessibility in Beilin District, Xi'an, China, demonstrated that the 2SFCA model was more suitable for short-distance walking scenarios because it represented the actual usage of community care facilities.

2. Two-Step Floating Catchment Area (2SFCA) Model

The two-step floating catchment area (2SFCA) model measures spatial accessibility in two steps. First, it determines the number of people in the neighborhoods near each elderly care facility to calculate the supply–demand ratio within the search radius. Then, for each residential area, it searches all elderly care facilities within the threshold travel time and determines the supply–demand ratio to derive the accessibility value of the residential area. The 2SFCA method is widely used for the evaluation of accessibility in public service facilities such as healthcare services [9], schools, elderly care facilities, and green spaces, where the green-space-accessibility-related studies have become a research hotspot in recent years [10], and the Gaussian 2SFCA method is generally used.

The previous literature shows that improvements in the 2SFCA model in recent years have focused on four aspects: the first aspect is to extend the model by adding spatial decay weights; Luo and Qi developed an enhanced 2SFCA (E2SFCA) model [11]. This model divides travel time into discrete time periods and assigns different weights to the different time periods. Other researchers use continuous functions such as kernel density [12] or Gaussian function to calculate the weights. The second aspect is to adjust the search radius based on specific accessibility factors, such as population density and facility level [13]. For example, if the population density is low in some areas of the study area and the conventional search radius cannot cover the effective residential areas, then the search radius is reset. The third area of focus is to extend the supply-and-demand model embedded in 2SFCA [14], which takes into account the competition between facilities and considers that the demand for care in one facility is influenced by the nearby facilities, thus affecting the specific choice of the person. Combining the Huff model with the 2SFCA model (Luo, 2014) [15], a modified 2SFCA model was proposed [16], which calculates the paired supply ratio for each population unit and hospital. These models add choice weights to each healthcare facility to simulate the population's preferences. The fourth aspect focuses on the travel behavior from the location of the population to the corresponding supply point location. Langford [17] argued that patients using different modes of transportation should have different travel time thresholds, and they modified the 2SFCA model to calculate the separate supply–demand ratios for different modes of transportation.

Although the model has been continuously improved by scholars over the years, most studies still analyze the accessibility of the facilities in terms of administrative areas. These studies mainly use census data to represent the number of inhabitants, assuming that the population of an area is evenly distributed and remains constant over time; meanwhile, in order to simplify the model, most studies do not take factors of the actual road network characteristics into account, which means that the entire supply–demand relationship is static and limited to the residential area of each potential demand object. This leads to the problem of uncertain geography [18], resulting in an inaccurate measurement of spatial accessibility [19]. This issue is particularly important for analyzing the demand for sensitive services in medical-type elderly care facilities and other similar contexts. When more urgent services are needed, the elderly population needs to be served from a geographic setting in their current location, as characterized by a specific road network. Therefore, assuming that all groups of the elderly population in the study area are potential service users, the researchers expect the relevant institutional accessibility values to vary according to different road network characteristics, taking into account the factor that the elderly population's mode of travel is primarily walking. The researchers adjusted the catchment radius thresholds based on this characteristic. In the neighborhood unit theory, created by American sociologist Clarence Perry in 1929 when he developed the New York Regional Plan, the ideal radius of a neighborhood is between 400 m and 800 m, where 800 m corresponds to about a 10 min walk [20]. Considering that elderly people can be slower than healthy younger people in terms of walking speed, the study by Padeiro [21] concluded that the maximum acceptable time it should take for an elderly person to walk to the nearest pharmacy is 15 min by asking 30 elderly people; at an average speed of 0.8 m/s, an elderly person will walk 720 m in 15 min, which is less than 800 m. Based on the above neighborhood unit theory and the walking range of the elderly population, the mathematical model in this research sets 800 m as the threshold value.

References

1. Trinkoff, A.M.; Yoon, J.M.; Storr, C.L.; Lerner, N.B.; Yang, B.K.; Han, K. Comparing residential long-term care regulations between nursing homes and assisted living facilities. Nurs. Outlook 2020, 68, 114–122.
2. Department of Economic and Social Affairs, United Nations, Population Division. World Population Ageing 2013; United Nations Publications: New York, NY, USA, 2013.
3. Joy, M. Problematizing the age friendly cities and communities program in Toronto. J. Aging Stud. 2018, 47, 49–56.
4. Wang, Y.; Fukuda, H. Sustainable Urban Regeneration for Shrinking Cities: A Case from Japan. Sustainability 2019, 11, 1505.
5. National Bureau of Statistics of China. Statistical Communiqué of the People's Republic of China on 2019 National Economic and Social Development; China Statistics: Beijing, China, 2020.
6. Lee, S.Y.; Kim, J.H. Effects of servicescape on perceived service quality, satisfaction and behavioral outcomes in public service facilities. J. Asian Archit. Build. Eng. 2014, 13, 125–131.
7. Zhou, Z.; Matteson, D.S. Temporal and Spatio-temporal models for ambulance demand. In Healthcare Analytics; Yang, H., Lee, E.K., Eds.; John Wiley & Sons: Hoboken, NJ, USA, 2016; pp. 389–412.
8. Liu, S.; Wang, Y.; Zhou, D.; Kang, Y. Two-Step Floating Catchment Area Model-Based Evaluation of Community Care Facilities' Spatial Accessibility in Xi'an, China. J. Environ. Res. Public Health 2020, 17, 5086.

9. Cheng, G.; Zeng, X.; Duan, L.; Lu, X.; Sun, H.; Jiang, T.; Li, Y. Spatial difference analysis for accessibility to high level hospitals based on travel time in Shenzhen, China. Habitat Int. 2016, 53, 485–494.
10. Liu, Z.; Yang, H.; Xiong, W.; Chen, G. Spatial accessibilities of medical services at county level based on optimized Two-step Floating Catchment Area Method. Sci. Geogr. Sin. 2017, 37, 728–737.
11. Luo, W.; Qi, Y. An enhanced two-step floating catchment area (e2sfca) method for measuring spatial accessibility to primary care physicians. Health Place 2009, 15, 1100–1107.
12. Dai, D.; Wang, F. Geographic disparities in accessibility to food stores in southwest Mississippi. Environ. Plan. B Plan. Des. 2011, 38, 659–677.
13. Kim, Y.; Byon, Y.-J.; Yeo, H. Correction: Enhancing healthcare accessibility measurements using gis: A case study in Seoul, Korea. PLoS ONE 2018, 13, e0194849.
14. Wan, N.; Zou, B.; Sternberg, T. A three-step floating catchment area method for analyzing spatial access to health services. Int. J. Geogr. 2012, 26, 1073–1089.
15. Luo, J. Integrating the huff model and floating catchment area methods to analyze spatial access to healthcare services. Trans. GIS 2014, 18, 436–448.
16. Delamater, P.L. Spatial accessibility in suboptimally configured health care systems: A modified two-step floating catchment area (m2sfca) metric. Health Place 2013, 24, 30–43.
17. Langford, M.; Higgs, G.; Fry, R. Multi-modal two-step floating catchment area analysis of primary health care accessibility. Health Place 2016, 38, 70–81.
18. Kwan, M.-P. The uncertain geographic context problem. Ann. Assoc. Am. Geogr. 2012, 102, 958–968.
19. Fransen, K.; Neutens, T.; De Maeyer, P.; DeRuyter, G. A commuter-based two-step floating catchment area method for measuring spatial accessibility of daycare centers. Health Place 2015, 32, 65–73.
20. Li, Q. From Neighborhood Units to New Urbanism Community—A Study on the Change of American Community Planning Model. World Archit. 2006, 7, 92–94.
21. Padeiro, M. Geographical accessibility to community pharmacies by the elderly in metropolitan Lisbon. Res. Soc. Adm. Pharm. 2018, 14, 653–662.

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