Analysis of Kindergarten Enrollment Accessibility and Influencing Factors in the Main Urban Area of Lanzhou City (Postprint)

Authors: Guo Nianfa, Wang Lucang

Date: 2025-06-20T00:00:00+00:00

Abstract

As the "low-lying area" in the education system, the precise quantification of kindergarten enrollment accessibility facilitates the evaluation of spatial allocation efficiency of preschool education resources. Taking the main urban area of Lanzhou as a case study, this research integrates data such as kindergarten POIs, school-age child population, number of available seats, and road hierarchy, employs kernel density analysis and a multi-level multi-mode Gaussian accessibility algorithm to quantify the agglomeration characteristics and enrollment accessibility of different-grade kindergartens, and utilizes spatial regression models and bivariate spatial autocorrelation to explore the influencing factors of enrollment accessibility distribution. The results indicate: (1) Kindergartens overall exhibit a belt-shaped distribution characterized by "one core" and "four centers," with density decreasing from east to west; provincial-standard kindergartens, municipal-standard kindergartens, district-standard kindergartens, and ordinary kindergartens basically show a "single-core"spatial distribution pattern. (2) The overall enrollment accessibility level of kindergartens demonstrates a spatial bias of "eastward-biased center of gravity" and "better in the south, worse in the north," while enrollment accessibility of different-grade kindergartens all exhibits polycentric structural characteristics. Among the four types of graded kindergartens, ordinary kindergartens have the most high-value areas in enrollment accessibility, reflecting their primary role in facilitating neighborhood enrollment for young children. (3) School-age population, household economic status, and kindergarten enrollment quotas have significant positive effects on enrollment accessibility, while road network density and bus stops have negative effects on enrollment accessibility, though the correlations are not significant. Additionally, kindergarten tuition fees also have a negative effect on enrollment accessibility.

Full Text

Analysis of Kindergarten Enrollment Accessibility and Its Influencing Factors in the Main Urban Area of Lanzhou City

GUO Nianfa[1], **WANG Lucang**[1,2]

[1]School of Geography and Environmental Science, Northwest Normal University, Lanzhou 730070, Gansu, China
[2]Key Laboratory of Resource Environment and Sustainable Development of Oasis, Lanzhou 730070, Gansu, China

Abstract

As a foundational yet often overlooked component of the education system, the precise quantification of kindergarten enrollment accessibility is crucial for evaluating the spatial allocation efficiency of preschool education resources. This study examines the main urban area of Lanzhou City, integrating data on kindergarten locations, school-age children, available places, and road classifications. Using kernel density analysis and a multi-level, multi-travel-mode Gaussian accessibility algorithm, we quantify the agglomeration characteristics and enrollment accessibility of different kindergarten tiers. Spatial regression models and bivariate spatial autocorrelation are employed to explore the factors influencing accessibility distribution. The results reveal that: (1) Kindergartens exhibit a "one core, four centers" banded distribution pattern, with density decreasing from east to west. Provincial-standard, municipal-standard, district-standard, and general kindergartens each display distinct "single-core" spatial distribution characteristics. (2) Overall kindergarten accessibility shows an eastward-weighted, "south-superior, north-inferior" spatial bias. Accessibility across different quality tiers demonstrates a "multi-center" structural pattern, with general kindergartens having the most high-accessibility zones, reflecting their primary role in facilitating local enrollment. (3) School-age population, family economic status, and kindergarten enrollment quotas exert significant positive effects on accessibility, while road network density and bus stops show negative but non-significant effects. Additionally, kindergarten tuition fees negatively impact accessibility.

Keywords: kindergarten; spatial distribution; enrollment accessibility; influencing factors; main urban area of Lanzhou City

1. Introduction

Following social development and improvements in livelihoods, parental attention to kindergarten education has shifted from "access to schooling" —an issue of equitable opportunity and balanced distribution—to "quality schooling" —

a matter of outcome equity and high-quality balance. Kindergarten education represents a critical dimension of urban public services, where the rationality and equity of spatial configuration directly affect children' s educational convenience. After 1978, under the "work-unit" and "street-neighborhood" population management systems, preschool education was fully managed by "work units" and "collectives," giving kindergartens distinct characteristics of unit welfare and public ownership. After 1992, China' s social transformation gradually dismantled the work-unit system, transitioning preschool resource allocation to a "socialized" configuration stage, with private kindergartens proliferating rapidly. By 2004, private kindergarten numbers first exceeded public ones, accounting for 52.76% of the total. By 2018, private kindergartens comprised 62.7% of the total, establishing a pattern dominated by private institutions and making preschool education the most marketized sector within the national education system.

Market mechanisms have led to rapid expansion of various private kindergartens, bringing issues of inadequate management, unqualified teachers, and declining educational quality. Meanwhile, public kindergartens inherited from the work-unit welfare system, with their strong resource acquisition capabilities and relatively standardized operations, maintain a "demonstration" status. The substantial "welfare gap" between these systems has become a primary contradiction in educational public services, further triggering problems of "difficult enrollment" and "expensive enrollment." In 2021, the National Development and Reform Commission and other 14 ministries issued the "Guiding Opinions on Promoting Child-Friendly City Construction," emphasizing the need to "improve inclusive preschool education guarantee mechanisms, further enhance 普及普惠水平, strictly implement policies for kindergartens in residential communities, fill resource gaps, and improve education quality." Therefore, examining the spatial configuration and accessibility of kindergarten resources is significant for achieving livable, green, safe, resilient, and smart urban development.

Kindergarten enrollment accessibility represents the convenience for children to overcome spatial and temporal barriers between home and kindergarten, reflecting the spatial layout and availability of resource allocation. Common accessibility methods include the ratio model, shortest distance method, potential model, and two-step floating catchment area (2SFCA) method. The ratio model lacks consideration of intra-regional differences, while the shortest distance method ignores supply-demand effects on accessibility. Both the potential model and 2SFCA consider supply and demand scales and distance effects, differing primarily in distance treatment. The potential model does not impose a maximum service radius on facilities, whereas 2SFCA uses a dichotomous distance approach that effectively identifies low-accessibility areas. Accessibility metrics primarily reveal potential opportunities for equitable resource access, with school selection representing the materialization of these opportunities.

Research on kindergarten selection factors has focused on "supply" and "demand" perspectives. The supply perspective examines educational resource allocation,

fiscal constraints, and government planning, while the demand perspective investigates family income, parental education, and school selection preferences. Studies have found that school-age population, per capita GDP, and education expenditure are primary factors influencing enrollment accessibility in Dongguan City. Although academic research on kindergarten resources has deepened, limitations remain in research objects, data sources, methods, and scales. First, kindergartens are often treated as homogeneous, ignoring the four-tier classification system (provincial demonstration, municipal demonstration, district demonstration, and general kindergartens). This homogenization obscures how children access educational resources under differentiated scales. Second, studies often use 0-5 year-old population data as a proxy for school-age children, inadequately responding to demographic characteristics. Additionally, accessibility research typically calculates based on single travel modes, neglecting the time costs associated with multiple travel options and their flexibility.

This study addresses these gaps by employing a multi-level, multi-mode Gaussian 2SFCA method to examine kindergarten resources, providing a scientific basis for optimizing educational resource allocation. Using 200m grids as the basic analytical unit and Lanzhou' s main urban area as the case study, we analyze kindergarten accessibility through kernel density analysis and multi-level, multi-mode Gaussian two-step floating catchment area methods.

1.1 Study Area

Lanzhou is a pivotal inland hub city in Northwest China. Constrained by natural geography, the main urban area is compressed within a narrow valley between northern and southern mountains, resulting in poor accessibility. This study focuses on the main urban area (25 streets in Chengguan District, 8 in Anning District, 17 in Qilihe District, and 10 in Xigu District) to analyze kindergarten accessibility. According to the municipal education bureau, by the end of 2022, Lanzhou' s districts had 73,800 kindergarten children across 531 kindergartens. Within the main urban area, there are 477 kindergartens, including 33 provincial-standard, 67 municipal-standard, 78 district-standard, and 299 general kindergartens. As urbanization accelerates, the number of children from migrant families settling in Lanzhou increases annually, while the valley topography—with limited land and dense population—poses significant challenges for kindergarten spatial planning.

1.2 Data Sources

Research data includes kindergarten POI data, road network data, kindergarten capacity, kindergarten tier classifications, and school-age child data. Specifically: (1) Kindergarten POI data were obtained through web scraping from Amap in 2022, preprocessed via coordinate system conversion and clipping, with capacity data entered into the attribute table. (2) Kindergarten tier classifications were obtained from Lanzhou Education Bureau' s official evaluation data, including operational nature, tier level, and inclusive type attributes. (3) Road network

data were derived from 2022 Amap vector data, georeferenced in ArcMap against Lanzhou' s "one horizontal, three rings, nine verticals" internal road system to obtain road classification attributes. (4) School-age child data for 0-5 years were estimated using a multiple linear regression model fitted with street-level data from the Seventh Population Census and Worldpop population grid data.

1.3 Methods

1.3.1 Kernel Density Analysis Kernel density analysis is a widely used spatial method for estimating unknown density functions. The calculation formula follows relevant literature [**?**].

1.3.2 Multi-Level, Multi-Travel-Mode Enrollment Accessibility Measurement Kindergarten selection typically follows proximity principles, where attraction decreases with distance. This pattern aligns with Gaussian functions that initially accelerate then decelerate in decline, making the Gaussian function appropriate as an impedance function. With improved public transport and private vehicle 普及, enrollment modes include walking, cycling/e-biking, bus, and car. Different road classifications affect travel speeds across modes, influencing enrollment efficiency. Based on Amap data, we assigned travel speeds for four modes across road classifications (Table 1).

Table 1 Traffic speed of four travel modes under each road level (km/h)

Road Level	Walking	Cycling/E-bike	Bus	Car
Expressway	5.0	15.0	40.0	60.0
Arterial	4.5	12.0	25.0	40.0
Secondary	4.0	10.0	20.0	30.0
Branch	3.5	8.0	15.0	20.0

Enrollment mode selection is distance-dependent. According to Wang et al. [**?**], within 0.3 km, walking dominates; within 0.3-1 km, cycling/e-biking dominates; within 1.5 km, bus dominates; and beyond 2.5 km, car dominates. Based on the "Lanzhou Citizens' Travel Mode Selection Survey Report," the proportion of children using different modes is calculated based on home-school distance (Table 2). Additionally, urban kindergarten enrollment time is typically within 15 minutes. Under tiered kindergarten systems, higher-tier kindergartens have stronger attraction. Following Cheng et al. [**?**] and the "3-6 Year-Old Children' s Learning and Development Guidelines," we set different search radii for various kindergarten tiers (Table 3).

Table 2 Proportion of population under each travel mode

Travel Mode	Proportion
Walking	0.56
Cycling/E-bike	0.12
Bus	0.26
Car	0.06

Table 3 Service radius of kindergartens of different levels

Kindergarten Tier	Service Radius (km)
Provincial-standard	2.0
Municipal-standard	1.5
District-standard	1.0
General	0.8

Step 1: Using kindergarten capacity as supply point j, with service radius d_r for a given tier, we aggregate all children within the search domain, weight them using the Gaussian function, and calculate the supply-demand ratio (R_j):

$$R_j = \frac{S_j}{\sum_m \sum_{i \in \{d_{ij}^m \le d_r^m\}} p_i^m \times G_K}$$

where k represents kindergarten tier; S_j is kindergarten capacity; m is travel mode; d_{ij}^m is travel time from grid centroid i to school j under mode m; d_r^m is the search radius for a given tier under mode m; p_i^m is the number of children traveling from grid i under mode m; and G_K is the Gaussian weight function:

$$G_K = \exp\left(-\beta \frac{d_{ij}^2}{d_r^2}\right)$$

where β is the distance friction coefficient. Following Cheng et al. [**?**], β values are 0.5, 0.8, 1.0, and 1.2 for provincial, municipal, district, and general kindergartens respectively. When $d_{ij} > d_r$, $G_K = 0$.

Step 2: Using grid centroid i as the origin, with service radius d_r^m for mode m, we identify supply points j within the search domain, weight their R_j values using the Gaussian function, and sum them to obtain accessibility (A_i^m) for mode m:

$$A_i^m = \sum_{j \in \{d_{ij}^m \le d_r^m\}} R_j \times G_K$$

Step 3: Accessibility varies across travel modes, ranking as: walking > cycling/e-bike > bus > car. Using the Analytic Hierarchy Process (AHP), we determined mode weights via Spsspro, achieving a consistency ratio of 0.044 (<0.1), passing the consistency test. The comprehensive accessibility (A_i) is:

$$A_i = 0.56 \times \text{Walking} + 0.12 \times \text{Cycling/E-bike} + 0.26 \times \text{Bus} + 0.06 \times \text{Car}$$

1.3.3 Spatial Regression Model Spatial regression models examine spatial associations in geographic phenomena [**?**]. The Lagrange Multiplier (LM) test determines the optimal model. After Ordinary Least Squares (OLS) regression, the LM-lag test was non-significant, while the LM-error test was significant, indicating the Spatial Error Model (SEM) better explains spatial effects:

$$y = \rho W_y + X\beta + \varepsilon$$

where y is the dependent variable (overall kindergarten accessibility); X are independent variables; β are coefficients; W_y is the spatial lag term; ρ is the spatial lag coefficient; and ε is the error term.

Kindergarten location directly affects accessibility, closely related to permanent population, education fiscal investment, and transportation [**?**]. We constructed indicators from supply-demand perspectives (Table 4):

Table 4 Explanatory variables

Variable	Description	Data Source
School-age children	Sum of 0-5 year-olds per grid	Worldpop, Lanzhou Yearbook, 7th Census
Family economic status	Average community housing price per grid	Lianjia, Anjuke real estate websites
Road network density	Road network density per grid	Amap vector data
Bus stops	Number of bus stops per grid	Amap POI data
Kindergarten tuition	Tuition fees by tier	Lanzhou Education Bureau
Enrollment quota	Autumn enrollment numbers by tier	Lanzhou Education Bureau

1.3.4 Bivariate Spatial Autocorrelation Bivariate spatial autocorrelation analyzes spatial correlation and dependency between accessibility and independent variables, visualized using LISA cluster maps. Formulas follow relevant literature [**?**].

2. Results

2.1 Spatial Distribution Characteristics

2.1.1 Overall Kindergarten Distribution Kindergarten density follows the pattern: Chengguan > Qilihe > Anning > Xigu, with a clear "one core, four centers" structure (Figure 2). The "core" is a high-density zone around Yannan, Yanbei Streets, and the High-tech Zone, with concentration far exceeding other areas. This core formation results from multiple factors: the High-tech Zone, formerly an old city district and national high-tech industrial development park, hosts numerous research institutions like the Lanzhou Institute of Physics, Chinese Academy of Sciences, forming a typical education center that attracts kindergarten resources. Yannan and Yanbei Streets, developed during Lanzhou' s eastward expansion, contain large commercial residential communities (Jindi Garden, Jinhe Community, Tianqingshe) with dense populations and strong demand for kindergarten resources.

The four "centers" are: (1) Zhangye Road, Jiuquan Road, Wuyuan, and Guangwumen Streets in Chengguan; (2) Xiyuan, Xihu, Xizhan, and Dunhuang Road Streets in Qilihe; (3) Yintan Road, Kongjiaya, and Xilu Streets in Anning; (4) Xigucheng, Sijiqing, and Lintao Street Streets in Xigu.

Figure 2 [Figure 2: see original paper] Kernel density of kindergartens in the main urban area of Lanzhou City

2.1.2 Distribution by Kindergarten Tier Provincial, municipal, district-standard, and general kindergartens each show "single-core"distribution patterns. Provincial-standard kindergartens cluster around Jiuquan Road, Zhangye Road, and Guangwumen Streets—the true old city area with complex functions, concentrated quality educational resources (Lanzhou Experimental Primary School, Lanzhou No.1 Middle School), and strong linkages between school tiers that attract high-quality provincial-standard kindergartens (Figure 3a). Municipal-standard kindergartens center on Yannan, Yanbei, and Weiyuan Road Streets, where strong population attraction and demand drive resource allocation (Figure 3b). District-standard kindergartens concentrate in Xiuchuan, Tumen Dun, Xizhan, and Dunhuang Road Streets in Qilihe District (Figure 3c). General kindergartens' core overlaps with the overall kindergarten core around Yannan, Yanbei Streets, and the High-tech Zone (Figure 3d).

Figure 3 [Figure 3: see original paper] Kernel density of kindergartens of different grades in the main urban area of Lanzhou City

2.2 Accessibility Distribution Characteristics

2.2.1 Overall Accessibility Using geometric interval classification in ArcMap, we categorized overall kindergarten accessibility into five levels: high, relatively high, medium, relatively low, and low. Lanzhou shows an eastward-weighted, "south-superior, north-inferior" distribution pattern, with Chengguan-

Qilihe clusters outperforming Anning-Xigu clusters, and southern Yellow River areas superior to northern areas (Figure 4). High and relatively high accessibility zones are located at growth poles within each cluster, though economic development starting points differ, creating variations in high-accessibility grid quantities and proportions. Chengguan and Qilihe districts show prominent high accessibility with 1,042 and 1,013 grids respectively (10.5% and 10.2% of total). Low accessibility is prominent in Anning and Xigu districts with 3,553 and 3,847 grids (35.8% and 38.7% respectively).

Figure 4 [Figure 4: see original paper] Accessibility of all kindergartens in the main urban area of Lanzhou City

Table 5 Number and proportion of grids with different accessibility in each district

District	Low Accessibility	Relatively Low	Medium	Relatively High	High Accessibility
Chengguan	1,042 (10.5%)	1,013 (10.2%)	···	···	···
Qilihe	···	···	···	···	···
Anning	3,553 (35.8%)	···	···	···	···
Xigu	3,847 (38.7%)	···	···	···	···

2.2.2 Accessibility by Kindergarten Tier Accessibility across different tiers shows "multi-center" structural characteristics. Provincial-standard kindergartens have high-accessibility zones near the provincial government in Chengguan, Northwest Normal University in Anning, and Lanzhou University of Technology in Qilihe—areas with government institutions, enterprise compounds, and strong demand for quality resources, plus well-developed transport infrastructure (Figure 5a). Municipal-standard kindergartens have fewer high-accessibility zones, with relatively high zones forming "multi-centers" around the provincial government, Dongfanghong Square, Lanzhou University, Yannan/Yanbei Streets, Yintan Road/Kongjiaya/Peili Streets, and Jianlan Road/Dunhuang Road Streets (Figure 5b). District-standard kindergartens show prominent relatively high zones covering most of central Qilihe due to abundant schools and places (Figure 5c). General kindergartens have high-accessibility zones in all districts with "multi-center" distribution, reflecting their role in meeting most families' proximity needs (Figure 5d).

Figure 5 [Figure 5: see original paper] Accessibility of kindergartens of different grades in the main urban area of Lanzhou City

2.3 Influencing Factors Analysis

Spatial regression analysis (Table 6) and bivariate spatial autocorrelation (Table 7, Figure 6) reveal:

Table 6 Results of spatial regression analysis of the impact of each variable on accessibility

Variable	Coefficient	Significance
School-age children	0.324***	Positive
Family economic status	0.156***	Positive
Road network density	-0.087	Negative (n.s.)
Bus stops	-0.043	Negative (n.s.)
Kindergarten tuition	-0.201***	Negative
Enrollment quota	0.278***	Positive

Table 7 Correlation of variables with bivariate spatial autocorrelation results

Variable	Moran' s I	Significance
School-age children	0.412***	Positive
Family economic status	0.235***	Positive
Road network density	-0.098	Negative (n.s.)
Bus stops	-0.056	Negative (n.s.)
Kindergarten tuition	-0.187***	Negative
Enrollment quota	0.301***	Positive

School-age population shows positive correlation with accessibility, forming "high-high" clusters in central areas and "low-low" clusters in peripheral zones. Lanzhou' s valley topography creates a "banded, multi-center" population layout, with central areas attracting population through superior location and historical accumulation, naturally driving kindergarten expansion and increased enrollment quotas.

Family economic status positively correlates with accessibility. High-high clusters concentrate around Dongfanghong Square and the provincial government in Chengguan, where superior location, commercial/cultural facilities, and advanced transport networks create "high-high" agglomerations. Adjacent "low-high" areas reflect dense child populations with limited educational resources, revealing unequal access opportunities across economic strata.

Road network density and bus stops show negative spatial relationships with accessibility, but without statistical significance, contrasting with some street-scale studies finding positive correlations. Lanzhou' s valley morphology makes walking the primary mode for short-distance school transport. Dense road areas often suffer heavy traffic, road enclosures, and parking restrictions that impede walking, demonstrating that high road density does not equal high accessibility.

Kindergarten tuition negatively affects accessibility, while **enrollment quotas** positively affect it. Tuition is a primary consideration in kindergarten

selection. Under a tiered quality system, provincial, municipal, and district demonstration kindergartens charge higher fees than general kindergartens, creating financial burdens that reduce accessibility for middle- and low-income families. This reflects how the current education system fails to ensure equitable competitive opportunities. High-high tuition-accessibility clusters appear in demonstration kindergarten-dense areas, where parental pursuit of quality resources creates "educational gentrification" through spatial binding of high-tier kindergartens, high-income families, and high tuition fees.

Figure 6 [Figure 6: see original paper] Bivariate spatial autocorrelation between accessibility and respective variables

3. Discussion

This analysis of kindergarten enrollment accessibility and its influencing factors in Lanzhou' s main urban area provides references for optimizing preschool resource spatial configuration. First, planning should follow urban development and school-age population scales, with rational layout according to local conditions. For capacity-surplus areas like Yannan, Yanbei, and Jiuquan Road Streets in Chengguan, strengthen management to prevent further expansion and consolidate current quality. For capacity-deficient areas like Yanchang Road, Qingbaishi Street in Chengguan, and southern Xiuchuan Street in Qilihe, add kindergarten facilities to address urgent needs. Second, coordinate multiple government departments to optimize road network layout and formulate reasonable enrollment policies, such as staggered school schedules, to ensure safe travel and improve accessibility.

Study limitations remain. First, education department-led kindergarten planning estimates resource surplus based on street-level child populations and school scales under "proximity enrollment" and "single-school zoning" principles, while urban planning emphasizes "reasonable service radius," breaking enrollment zone boundaries. This creates spatial contradictions between "policy boundaries" and "planning boundaries." This study only calculates accessibility from reasonable planning radii for different tiers without considering enrollment zone impacts. Second, industrial relocation, residential demolition/construction, and uncertain fertility policies cause complex population aggregation, dispersion, and mobility, making precise school-age population prediction difficult and affecting accessibility calculations.

4. Conclusions

(1) Kindergartens show a "one core, four centers" banded distribution, with highest density in Chengguan District. High-density zones concentrate in resource-rich areas (commercial, cultural, transport, education), while low-density zones appear in economically underdeveloped, resource-poor areas —closely linked to Lanzhou' s eastward-expansion, westward-development urban planning history. Provincial, municipal, district-standard, and gen-

eral kindergartens each exhibit "single-core" distributions, where strong mobility of capital, land, and labor under market mechanisms creates intensive, compact resource allocation.

(2) Overall kindergarten accessibility displays an eastward-weighted, "south-superior, north-inferior" spatial bias. Peripheral low-accessibility areas face the dilemma of "high-end location but low-end resources," with low road network density and long distances to kindergartens. Accessibility across different quality tiers shows "multi-center" structures, with general kindergartens having the most high-accessibility zones, confirming their primary role in local enrollment.

(3) Spatial regression results indicate that school-age population, family economic status, and enrollment quotas significantly positively affect accessibility, as dense child populations drive kindergarten expansion and increased quotas, while affluent families can afford higher education costs. Road network density, bus stops, and tuition fees negatively affect accessibility, though the former two are non-significant—closely related to valley morphology and walking-dominant school transport in Lanzhou, where dense roads often have heavy traffic and restrictions that reduce accessibility. High tuition fees create financial burdens, forcing some families to forego high-quality kindergartens and reducing accessibility.

References

[1] Sha Li, Zhang Xiaojuan, Kang Liying. The creation and evolution of the concept of Kindergarten: Based on an analysis of historical semantics[J]. Educational Research, 2023, 44(9): 51-63.

[2] Li A-fang, Wang Xiaoying. The development logic of the supply subjects of preschool education in China based on the perspective of historical institutionalism[J]. Studies in Early Childhood Education, 2021(12): 13-22.

[3] Liu Qian. How to control the risk of the implementation of public private partnership model in early childhood education in China: From the perspective of international concern[J]. Educational Development Research, 2016, 36(20): 34-40.

[4] Cheng Fangping, Feng Fangfang. The evolution of the government' s role in the development of preschool education in China and its influencing factors[J]. Journal of Hebei Normal University (Educational Science Edition), 2024, 26(3): 114-124.

[5] National education supervision team' s special supervision and inspection bulletin on early childhood education[J]. Preschool Education Research, 2005(9): 5-6.

[6] Li Yan, Li Shaomei. A study on Chinese quality evaluation policy changes of kindergarten based on multiple streams theory[J]. Journal of Shaanxi Xueqian

Normal University, 2024, 40(5): 105-112.

[7] Tao Zhuolin, Dai Teqi, Song Changqing. Improving spatial equity-oriented location allocation models of urban medical facilities[J]. Acta Geographica Sinica, 2023, 78(2): 474-489.

[8] Li Bo. Spatial distribution characteristics and accessibility analysis of medical facilities in Dalian based on two-step mobile search method[J]. Geomatics & Spatial Information Technology, 2024, 47(5): 87-89.

[9] Tao Zhuolin, Cheng Yang. Research progress of the two-step floating catchment area method and extensions[J]. Progress in Geography, 2016, 35(5): 589-599.

[10] Song Zhengna, Chen Wen, Zhang Guixiang, et al. Spatial accessibility to public service facilities and its measurement approaches[J]. Progress in Geography, 2010, 29(10): 1217-1224.

[11] Zhang Yanlin, Li Min, Liu Yuwen, et al. Spatial accessibility analysis of primary educational resources based on student home address and geocoding: A case study in Zhuzhou County, Hunan Province[J]. Scientia Geographica Sinica, 2022, 42(6): 993-1004.

[12] Kong Yunfeng, Li Xiaojian, Zhang Xuefeng. Analysis of spatial accessibility for school redistricting in rural China: A case study of the secondary schools in Gongyi City, Henan Province[J]. Journal of Remote Sensing, 2008, 12(5): 800-809.

[13] Tang Pengfei, Xiang Jingjing, Luo Jing, et al. Spatial accessibility analysis of primary schools at the county level based on the improved potential model: A case study of Xiantao City, Hubei Province[J]. Progress in Geography, 2017, 36(6): 697-708.

[14] Lin Peng. A review of accessibility research methods[J]. Western Resources, 2022(1): 194-200, 202.

[15] Wang Jing, Gao Xiangdong. Research on spatial accessibility and equity evaluation to residential care facilities in Shanghai[J]. Shanghai Economy, 2018(3): 44-56.

[16] Zhang Jingxiang, Ge Zhibing, Luo Zhendong, et al. Research on equalized layout of urban and rural public facilities: A case study of educational facilities in Changzhou[J]. City Planning Review, 2012, 36(2): 9-15.

[17] Han Fei, Luo Renchao. Matching of supply and demand for community service oriented home care facilities based on accessibility measurement: A case study of Nanjing[J]. Economic Geography, 2020, 40(9): 91-101.

[18] Cheng Shunqi, Qi Xinhua, Lin Han, et al. The improvement and application of two-step floating catchment area method in measuring accessibility to educational public service: A case study of kindergartens in Fuzhou[J]. Human Geography, 2017, 32(3): 53-60.

[19] Dai Jiaxin. Research on the concept, measurement and influencing factors of accessibility: A literature review[J]. Learning and Practice, 2017(4): 86-94.

[20] Wang Fan, Bai Yongping, Zhou Liang, et al. Spatial pattern and influencing factors of the equalization of basic education public service in China[J]. Geographical Research, 2019, 38(2): 285-296.

[21] Mo Huibin, Luo Ke, Wang Shaojian, et al. Spatial heterogenicity and mechanism difference of restaurant in the central urban area of Guangzhou: A comparison between traditional restaurant and take-out restaurant[J]. Geographical Research, 2022, 41(12): 3318-3334.

[22] Wang Shiqiong, Liu Rui, Dai Jicai, et al. Availability differences and influencing factors of rural compulsory education resources in Chongqing[J]. Tropical Geography, 2022, 42(8): 1349-1362.

[23] Huang Tao, Wang Yanhui, Guan Hongliang, et al. Research on the coupling characteristics of time and space between rural basic public services and multidimensional poverty under the background of rural revitalization[J]. Human Geography, 2021, 36(6): 135-146, 192.

[24] Zhang J, Yue W, Fan P, et al. Measuring the accessibility of public green spaces in urban areas using web map services[J]. Applied Geography, 2021, 126: 102381.

[25] Wang Xia, Chen Xiaojian, Jiao Jian. Accessibility of urban primary schools based on family travel behavior: A case study of Xi'an[J]. City Planning Review, 2015, 39(12): 64-72.

[26] Zheng Luanjuan, Xiao Tong, Liu Ye, et al. Using multiple travel mode two-step floating catchment area (2SFCA) approach to measure the spatial accessibility of primary schools in Dongguan City, China[J]. Progress in Geography, 2023, 42(7): 1341-1354.

[27] Wang Zilin, Li Zhigang, Cheng Hanbei. The equity of urban park green space accessibility in large Chinese cities: A case study of Wuhan City[J]. Progress in Geography, 2022, 41(4): 621-635.

[28] Cheng Fanfan, Bai Yongping, Liang Jianshe, et al. Spatial distribution characteristics and influencing factors of vegetable markets in Lanzhou City[J]. Arid Land Geography, 2024, 47(2): 293-306.

Note: Figure translations are in progress. See original paper for figures.