

Simulation of spatialization of population in urban living areas

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Abstract

Population distribution is an important aspect of analyzing urban spatial structure. Nowadays, spatialization simulation of urban living area population is on the rise, this paper focuses on the delineation of living area and simulation of heterogeneous population characteristics, taking Lanzhou main city as an example, using multi-source data and function fitting to analyze the state of population distribution in the urban living area. The study shows that: (1) within the 5-min, 10-min, and 15-min living area, the total population and the population with different characteristics have a roughly equal relationship between the population mean and the population standard deviation of 1:4:10 and 1:3.5:8, and that the male population has the same relationship between the population mean and the population standard deviation of the male population as that of the female population, while the proportion of the population mean for the child population is slightly lower than that of the elderly population, and the proportion of the population standard deviation is slightly higher than that of the elderly population. (2) With the expansion of 5-min, 10-min and 15-min living circles, the ratio of the elderly to the young and the sex ratio has evolved from a fragmented feature to a concentrated and piecemeal spatial pattern. The core area of urban development has a high level of age-age ratio, and the peripheral area of the city has a low level of age-age ratio, presenting a "higher-medium-lower" intertwined circle structure; the value of the sex ratio of the population in the three-level living circle of the peripheral area of the city is high, and the value of the sex ratio of the population in the inner core area is low, and the high value area is nested in the higher value area. High-value areas are nested in higher-value areas and low-value areas are nested in lower-value areas, and in some areas there is a phenomenon of high-value and low-value "poles next to each other". (3) The ratio of the total population in the central, marginal and peripheral zones is 1:0.74:0.24, and the ratio of the number of living circles is 1:0.72:0.32. The peaks and valleys of the total population in the sample zone and the number of population with different characteristics occur alternately, and the spatial distribution of the sample zone is characterized by the sparseness of the north-western part of the country and the density of the southeastern part of the country.

Keywords

City life circle; wp population raster; baidu heat map; population spatialization.

1. Introduction

After the reform and opening up, China's residential pattern has experienced a major shift from the lane system to the unit compound to the residential district [1], which has reshaped the external and endogenous environmental structure of the residential area, and has had a profound impact on the individual's living habits and behaviors. The urban living area is structured on the basis of the community, with human needs as the core, through a combination of different public facilities, to meet the needs of different groups of people [2], but the reality is that due to the inability to identify the spatial distribution of the population within the living

area, the government, real estate, planners, multiple forces of the hostage, the interests of the community residents are not enough to pay attention to the interests of the community groups, especially in the lowlands of the economic development, " Especially in the lowlands of economic development, the concept of "people's city built by people" exists in name only [3], which leads to multiple problems such as public satisfaction with the use of infrastructure [4], accessibility and fairness of service facilities [5], and matching the quality of the type of service facilities with the supply and demand [6]. Along with the establishment of market economy and the implementation of residential commercialization policy, the spatial transformation and reconstruction within Chinese cities, the tendency of residential space differentiation deepens, and the differences between high, middle and low-income residents in terms of location, transportation, environment and housing zone selection are highlighted, which triggers the lack of a sense of belonging of the residents [7], separation of jobs and housing [8], pendulum traffic [9], social segregation [10], and imbalance of the urban order [11], and other problems. The essence of these problems is that under the economic model of free market as the main regulating mechanism, the accumulation of capital free flow cycle leads to spatial distribution imbalance or is derived from this, while the study of community living area is based on the demographic structure and demand changes, and puts forward the improvement and enhancement requirements of community planning practice to keep pace with the times, which can better respond to the people's aspirations for a better life, and enhance the sense of access and happiness of the citizens.

The concept of living sphere was first traced back to Japan [12], after World War II, Japan's rapid population-concentrated urbanization, resulting in the merger or permanent disappearance of traditional villages, serious environmental pollution, widening the gap between urban and rural areas, rural environmental degradation and other problems, in this reality, the Japanese government for the first time put forward the concept of the "wide-area living sphere," which is intended to achieve The concept of "wide-area living sphere" was first introduced by the Japanese government in order to realize the idea of balanced regional development, improvement of the urban environment, and suitable settlement of residents. China introduced the concept of "living area" in the early 1990s [13], and later defined it as "a basic unit within a suitable daily walking range that meets the needs of urban and rural residents for work and life throughout their life cycle, integrating multiple functions of workability, livability, nourishment, and learning, leading to a future-oriented, healthy, low-carbon, and beautiful lifestyle". It is also the basic unit to meet the needs of urban and rural residents in the whole life cycle of work and life, integrating the multiple functions of workability, livability, nourishment and learning, and leading a future-oriented, healthy and low-carbon way of life. At present, domestic research on living area has moved from basic issues such as delineation of service scope of living area [14], layout of community public service facilities [15] and convenience assessment [16] to upgrading issues such as sinking of community governance [17] and community resilience [18]. The living area connects "home" and "city", and as the baseline of urban management services, the issue of differentiated population distribution can never be bypassed in planning practice, facility layout, convenience assessment, and resilience enhancement, and the simulation of urban living area is the foundation and key to the development of urban living area planning practice. Simulating the heterogeneous population distribution characteristics is the basis and key to the practice of living area planning. However, due to the availability of data and methods, the response of living area planning practice to the demographic distribution characteristics of different groups of people is insufficient, and the precise allocation of living area elements needs to be further improved. Nowadays, the spatial development of national land has been transformed from incremental planning of "supply based on demand" to stock planning of "supplying and adjusting demand" [19]. Under the background of the strategy of new urbanization and high-quality development, scientific simulation of the demographic structure

of the urban living area is the key to responding to the changes in demand and equitably allocating public products, effectively managing population and urban governance, and satisfying the quality of life. Fair allocation of public products, effective population management and urban governance, and fulfillment of quality of life.

Based on this, this paper takes the main urban area of Lanzhou City as a case study, with the help of population raster data, Baidu heat map, seven universal and other related data, simulates the population distribution characteristics within the city with high precision, extracts the population of the living area on the basis of scientific delineation of the living area, fits the population of different age and gender characteristics of the living area, and then provides a reference for the refined management of the city.

2. Study region and data sources

2.1. Study region

Lanzhou is a hub city in the inland northwest of China, and the only provincial capital city in China where the Yellow River passes through the city. Influenced by the natural geographic conditions, the main urban area is squeezed in the narrow valley area of the north and south mountains, and the contradiction between people and land is highly tense. By the end of 2022, the city's resident population will be 4.4153 million people, the urban population will be 3.7118 million people, the population density will be 7,486 people/km², and the scale of the residential land will be 966,200 km² (Figure. 1).

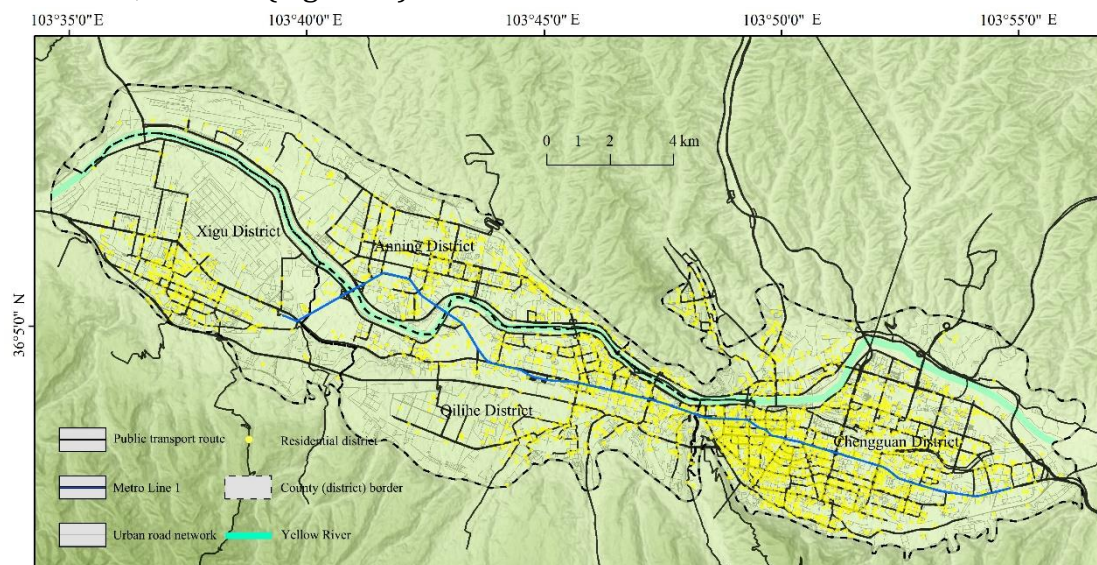


Figure 1 Overview map of the study area

2.2. Data sources

Data sources include the “China population 2020” grid data in Worldpop spatial statistics (referred to as WP population grid data, with a spatial resolution of 100m×100m), Baidu heat maps, road network data, multiple POI data, SevenPop data, and related statistics, Among them: (1) main city boundary data: apply to call the API key code of Gaode map web base service, use Python3.9 program to get the administrative division data of Lanzhou city in 2022, based on the built-up area scope determined by the fourth edition of Lanzhou city planning, compare with the crawled administrative division data, borrow Arcmap software to carry out cropping and topology processing, and determine the good urban The scope of the main urban area is determined; (2) Multi-class POI data, road network data: obtained through Gaode Map web base service API geocoding, and cropped POI points and road network outside the main urban area, and finally obtained 3272 residential areas, 602 supermarkets, 286 flower, bird, fish, and

insect markets, 403 vegetable markets, 39 commercial streets, 950 bus stops, 27 subway stations, and 1305 drugstores, 1009 clinics, 216 health centers, 67 parks and squares, 58 cinemas and theaters, 490 KTVs, 495 kindergartens, 160 elementary school, 116 secondary schools, 13 fire stations, 64 metallurgical and chemical plants, and 23 train station entrances, and define their projections to CGCS2000_3_Degree_GK_CM_105E.

3. Research methods

3.1. Two-step correction of WP population grid data

According to the boundary of the main urban area, the WP population grid data is cropped to get the WP population grid data of the main urban area of Lanzhou City (Figure 2-a). Population spatialization is actually the process of spatial decomposition of population. At present, the most detailed spatial data of population is the street census data (Figure 2-b), which is difficult to correspond to the living area, and the WP population grid data, although better reflecting the “spatialization”, is rough in spatial expression and has a large error, so it is necessary to carry out a two-step correction.

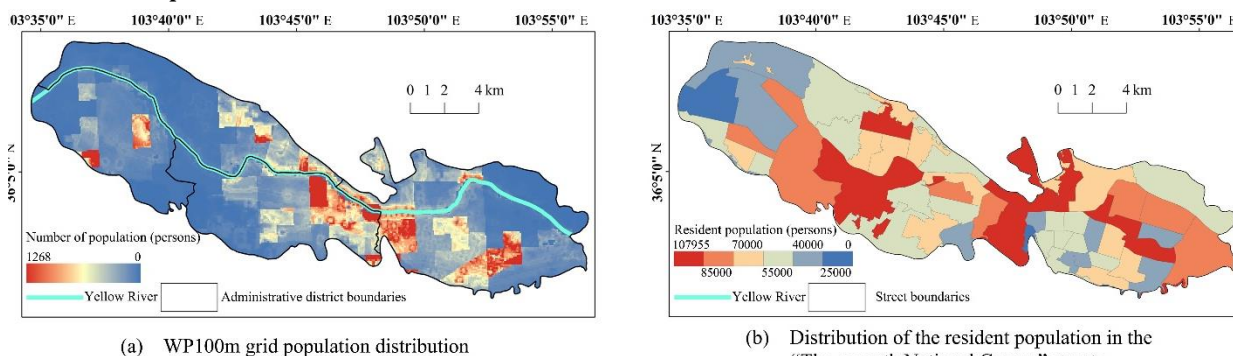


Figure 2 Distribution of wp population in Lanzhou City with sub-street demographics

Correction for the total population of the main urban areas: WP population grid data, the total population of 2117918 people; and “seven universal” data in the total population of 2905867 people, the difference between the two is 787949 people, so the total resident population of “seven universal” / WP population as a correction factor (1.372). /The difference between the two is 787,949 people, so the total resident population of the “Seven Population Census” is used as the correction coefficient (1.372). Since the “seven universal” statistics are summarized by administrative districts at each level, which is authoritative, systematic and standardized, the “seven universal” data are used as the test standard, and the “raster calculator” of Arcmap is used to input “1.372”, “1.372”, and “1.372”. Through Arcmap's “Grid Calculator”, inputting “1.372*WP population grid data”, the corrected total population can be obtained, and the result is very close to the “seven universal” data.

Corrections to the total population of the streets in the main urban area: according to the data of WP population grid in Lanzhou City, the total population of each street is counted; according to the data of Lanzhou City's population “seven universal”, the resident population of each street is counted, and then the correction coefficient for each street can be obtained, The calculation was as follows:

$$S_i = \frac{POP_{ij}}{POP_{wp}} \tag{1}$$

Where, S_i is Correction factor for each street; POP_{ij} is Number of Usual Residents by Street in the Seventh Population Census; POP_{wp} is total population of each street in “WP”.

Street shp file in Arcmap through the “surface to raster”, borrow the “raster calculator”, enter “surface to raster (including the street correction coefficient attributes) * 1.372 * WP

population grid data “ can get the total population of the corrected streets, the results are approximately equal to the population “seven universal” statistics of the total population of the streets in the central city. Through the two-step correction, the spatial distribution of population at the city scale and street scale can be obtained (Figure 3-a, Figure 3-b).

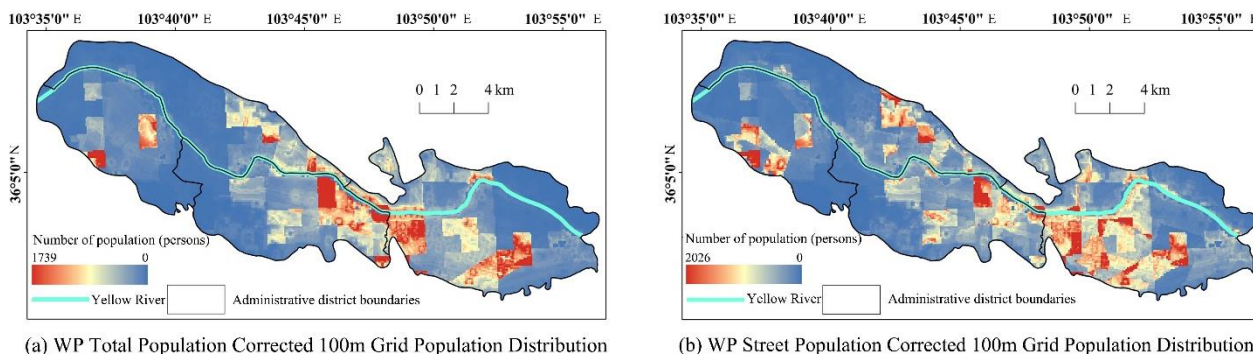


Figure 3 Two-step correction of wp population grid data

3.2. Baidu Heat Map Correction for WP Population Grid Data

Baidu Heat Map is a digital footprint with location and attribute labels based on smart mobile devices, which can clearly depict the spatial and temporal distribution of the population within a city. Because Baidu Heat Map Band1, Band2 and Band3 are color channels, which are displayed in the map as “black or white” effect, compared with Band4 (value range of 52~194), which uses 256 levels of grayscale to represent the heat map information, and the color of the picture there is a continuous relationship between the intervals and the color of the picture, so it will be Therefore, the “heat value of population concentration” is replaced by the “grayscale value of picture color” to classify the statistics, so that it can meet the requirements of scientific research.

Baidu heat map and WP population 100m grid both are continuous variable data , calculate the correlation between Population average and thermal average. The calculation was as follows:

$$\overline{POP} = \frac{\sum WP_{ij}}{\sum WP_i} \tag{2}$$

$$\bar{M} = \frac{\sum M_{ij}}{\sum M_i} \tag{3}$$

Where, \overline{POP} is Population average; $\sum WP_{ij}$ is Sum of “wp” population pixel values at street level; $\sum WP_i$ is Sum of the number of “wp” population pixels within the street. \bar{M} is thermal average; $\sum M_{ij}$ is Sum of thermal image point values at street scale; $\sum M_i$ is Sum of number of thermal image points at street scale.

In turn, to determine the correlation between population and heat on the like meta-unit, it was found that the Pearson correlation coefficient is 0.897, the correlation is very significant, which can be used linear regression model to fit the functional equation between the two, which the primary function, the quadratic function, the S-function fit is better .

With the help of the functional relationship between the two, the spatial distribution of population within the city can be modeled with high accuracy. The relative error is equal to the ratio between the simulated population and the resident population, the relative error >1 means that the simulated population is >resident population, the relative error <1 means that the simulated population is <resident population, the closer the relative error is to 1, the closer the simulated population is to the resident population, and the better the simulation effect is (Figure 4).

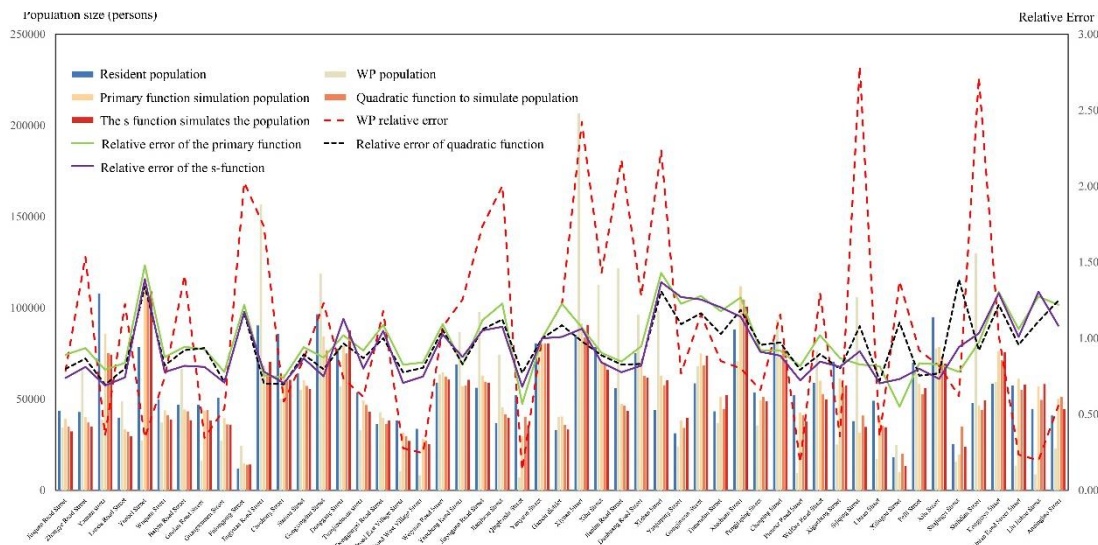


Figure 4 Chart of relative errors in the enumerated population

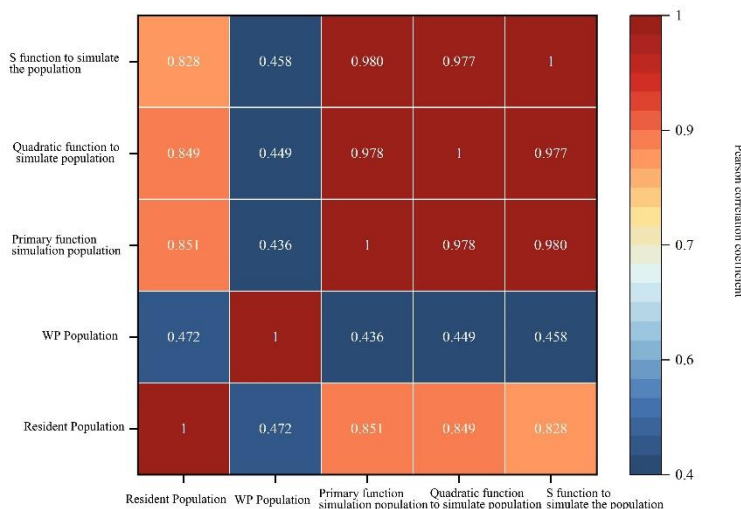


Figure 5 Fit of different function models

Through the correlation analysis between “resident population” and “WP population”, “primary function simulated population”, “quadratic function simulated population”, “S function simulated population”, and the correlation approximation instead of the degree of fit, we further explore which function type is the best for the inner-city population. ““S function simulation population” correlation analysis, using the correlation approximation instead of the fit, to further explore which function type has the best fitting effect for the inner-city population, the results are shown in Figure 5, and it is found that the fit of the primary function is the highest, which is 0.851, and therefore the spatial distribution of the inner-city population can be simulated with high accuracy by the primary function. simulate the spatial distribution of the inner-city population with high accuracy.

3.3. Community Life Circle Scoping

At present, the most common practice in urban planning for the delineation of the scope of the living circle is to merge old neighborhoods and residential clusters, and take the street boundary as the scope of the living circle. This is inconsistent with the core concept of community life circle, which is “human-oriented” and “concerned with residents' daily life”, and does not break through the mold of “original community” [20].

In the "Lanzhou fifteen-minute living circle supporting institutions planning research and guidelines”, proposed to build Lanzhou city street - community two-level living circle system,

in the living circle system layout planning, emphasizing the service core of the living circle as far as possible in the central location of the layout of the living circle, and with the combination of public transportation nodes. However, from the existing city to build a 15-minute living circle planning implementation, single only based on the city's control detailed planning (upper planning), not in line with the normative indicators of the region to check and fill in the gaps. According to the street boundaries, the old neighborhoods are first merged to delineate the 15-minute living circle, the scope of which is basically overlapped with the street boundaries, and then the 5-minute and 10-minute living circles are delineated within the scope of the 15-minute living circle in the form of geometrical circles, which are followed up by the institutions at a later stage, ignoring the extensive existence of heterogeneity in the real city, and the lack of the reasonable expression of the intrinsic connotation of the living circle.

The "family" is the starting point and destination of residents' activities outside the home, therefore, the scope of the living circle is the spatial scope of residents' daily interaction activities based on the family [2], but if the scope of the living circle is defined based on the unit of the "family", it is not possible to take into account individual needs and daily behaviors, but it is not possible to unify the needs of individuals, which results in too many processing units and inconvenient to properly define the scope of the community living circle. However, if the "family" is used as the unit to define the scope of the living area, although it can take into account the individual's needs and daily behaviors, it is impossible to unify and integrate the individual's needs, which leads to too many processing units, complicated data, and inconvenience in defining the scope of the community's living area, so it is necessary to transform the individual into a group to analyze it from the perspective of the group. The home address is actually carried in the residential area, and the residential area carries a certain scale of people with group characteristics. Therefore, this paper takes the residential area as the origin to delimit the scope of community life circle.

3.4. Generation of demographic gradient zones and sample zones

To further explore what is the distribution of the population in the urban living area within the core and periphery of the city? What are the types of population changes in different age and gender characteristics? This paper takes Lanzhou city as an example to construct the population circle gradient belt and sample belt, in which: the demarcation of population gradient belt refers to the demarcation standard proposed by Zhou Yixing, Rao Chuankun and other scholars [21][22], and the circle is divided into circles with a radius of 5km. As the main city of Lanzhou City is east-west narrow river valley landscape, so the division of the circle is inevitably not Burgess standard concentric circle model review measurement, combined with the urban spatial pattern, elliptical model is more in line with the direction of the city. In addition, the urban population is essentially carried in the settlements, and the spatial distribution of the settlement agglomeration state implies the population distribution pattern, so the range of the center circle is determined on the basis of the standard deviation ellipse derived from the analysis of the POI data of the settlements. Meanwhile, referring to the division of urban spatial location types and hierarchical sequences by scholars such as Yang Wuyang and Han Fei [23][24], the three circle types from the center to the periphery are divided into the center zone (0-5km), the edge zone (5-10km), and the periphery zone (10-15km) in turn. The population sample zones, on the other hand, were delineated along the long axis of the elliptical circles, with the main urban area as the boundary.

4. Spatialization of the population in urban living areas

4.1. Statistics on the population of the living area

Based on the simulation of different characteristic populations within the city, the relevant characteristic populations are extracted according to the actual boundary range of 5-minute, 10-minute and 15-minute living circles, and the results are shown in Table 1:

(1) The mean values of the total population numbers of the three levels of living circles are 1551, 6004 and 15988 respectively, showing a quantitative relationship of 1:4:10, and the standard deviations of the total population are 1536, 5375 and 12592 respectively, showing a quantitative relationship of 1:3.5:8.2;

(2) The mean values of the number of children population in the three levels of life circle were 217, 830, and 2195 respectively, showing a quantitative relationship of 1:3.8:10.1=0.026, and the standard deviation of the children population was 224, 757, and 1766 respectively, showing a quantitative relationship of 1:3.3:7.8=0.038;

(3) The mean value of the number of elderly people in the three levels of living area is 193, 732 and 1926 respectively, showing a quantitative relationship of 1:3.7:10=0.027, and the standard deviation of the elderly population is 239, 831 and 1919 respectively, showing a quantitative relationship of 1:3.4:8=0.036;

(4) The mean values of the number of male population in the three levels of life circle are 794, 3081 and 8182 respectively, showing a quantitative relationship of 1:3.8:10.3, and the standard deviation of the male population is 778, 2720 and 6356 respectively, showing a quantitative relationship of 1:3.5:8.2;

(5) The mean values of the number of female population in the three life circles are 757, 2923 and 7790 respectively, showing a quantitative relationship of 1:3.8:10.3, and the standard deviation of the female population is 758, 2666 and 6261 respectively, showing a quantitative relationship of 1:3.5:8.2;

The total population and the population with different characteristics in the 5min, 10min and 15min life circle, the population mean and the population standard deviation ratio has the similarity, after rounding off roughly 1:4:10 and 1:3.5:8 quantitative relationship, due to the total population as a whole set of population with different characteristics of the population nested in the total population, so it has a certain degree of similarity, from which we can see the proportionate relationship between the number of different characteristics of the population. This allows us to see the proportionality of the different characteristics of the population. In addition, the male and female populations in the three levels of living area have the same proportion of population mean and standard deviation, while the proportion of children's population mean is slightly lower than that of the elderly population, and the proportion of standard deviation of the population is slightly higher than that of the elderly population.

Table 1 Tertiary Life Circle Total Population and Different Characteristics Statistical Data Table

Headcount/person	5-minute living area				10-minute living area				15-minute living area			
	Max	Min	avg	S.D	Max	Min	avg	S.D	Max	Min	avg	S.D
total population	9974	95	1551	1536	36091	117	6004	5375	62940	170	15988	12592
0-14 years	1502	15	217	224	5459	26	830	757	9147	28	2195	1766
≥ 65 year olds	1500	11	193	239	5975	17	732	831	9946	22	1926	1919
Male population	5201	52	794	778	17785	66	3081	2720	31134	89	8182	6356
Female population	4773	43	757	758	18306	55	2923	2666	32007	80	7790	6261

Note: Max is maximum values; Min is minimum value; avg is average value; S.D is standard deviation.

4.2. Spatial distribution of the demographic structure of the living area

Based on the number of old and young, gender population within the city obtained from the simulation, the calculation of old and young ratio and gender ratio is carried out, and the results are classified into five categories, namely, low, low, medium, high and high, using the natural breakpoint method, and then extracted and visualized and expressed through the actual range of the three-level living circle (Figure 6), and the results are analyzed as follows.

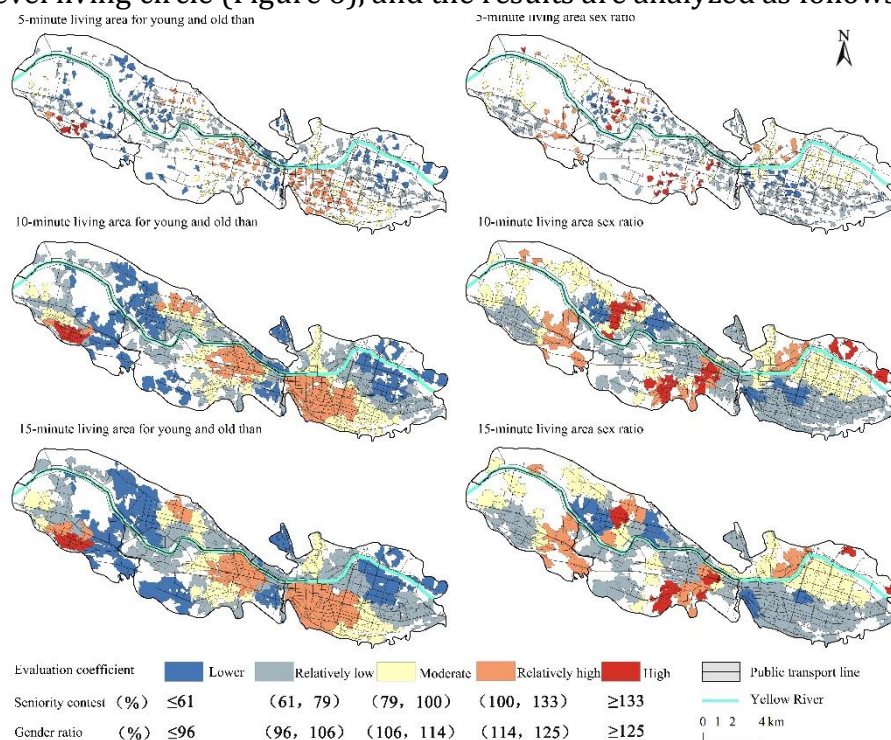


Figure 6 Spatial Distribution of Age and Sex Structure of Population in Tertiary Life Circle

4.2.1. Age structure of the population in the living area

Along with the expansion of the 5-minute, 10-minute and 15-minute living circles, the ratio of the elderly to the young has evolved from a fragmented character to a concentrated and piecemeal spatial pattern. The core area of urban development has a high level of old-age-to-child ratio, while the peripheral area of the city has a low level of old-age-to-child ratio, presenting a “higher-medium-lower” circle winding structure, and the value of old-age-to-child ratio of urban residential land is higher than that of other land use types. The high value of the living area is distributed in Fuli Road and Pioneer Road Street of Xigu District. Xigu District has been a typical industrial area of Lanzhou City during the First Five-Year Plan period, where Lanzhou Refining and Lanzhou Chemical Company invested and built factories, attracting many workers to gather and settle down, and Fuli Road and Pioneer Road Street belong to the residential land in the first edition of Lanzhou City Planning. After the completion of industrialization, industrial technology has improved the level of health care and slowed down the death of the population, and since urbanization, the cost of child rearing has generally increased and lowered the birth rate, and the double factors have resulted in a high ratio of old to young and a serious aging of the population.

The life circle of young and old is relatively high value area distributed in Chengguan District, Zhangye Road, Guangwumen, Fulongping, Baiyin Road, Gaolan Road, Jiuquan Road, Donggang West Road, Weiyuan Road, Railway East Village, Railway West Village, Unity Village, Wuquan Street, Qilihe District, the West Railway Station, Xihu, Jianlan Road Street, West Road, Annin District, Kongjiaya Street, as well as the Xigucheng Street of the Xigu District, the areas originally belonged to the government's planning of the residential land, the formation of a typical

phenomenon of integration of work and residence, the emergence of a large number of unit family homes, the old generation of local residents gathered here to live, by the traditional attachment to the land and living habits. In the background of the era of “unit-run society”, the formation of the typical phenomenon of integration of work and residence, the emergence of a large number of units of the family home, the old generation of local residents gathered here to live, by the traditional love of the plot and living habits, the local elderly living here for a long time, in situ aging, and in addition, due to the complete provision of these areas of medical care facilities for the elderly, the level of welfare. In addition, because these areas are well-equipped with medical and pension facilities and have high welfare levels, and belong to the core and center of the provincial capital city development, they attract the elderly population to move in and enter the aging area, which is a result of multiple factors that lead to a high ratio of old to young people at all levels of the living area within the street.

The middle area of the living circle with the ratio of young to old is distributed around the higher-value area, the lower-value area is distributed around the middle area, and the lower-value area is distributed in the periphery of the city. After the establishment of the market economic system, the income gap between farmers farming and working outside has widened, and the agricultural population has moved to the city, and a large-scale young agricultural migrant population has emerged in the peripheral areas of the city, which has given rise to a large number of just-demanding housing needs. With the revolutionary changes in the housing system and land use system, most of the peripheral areas of the city have become the commercial residential areas prioritized for development of real estate, and the migrant workers have rented housing and stayed temporarily. Migrant workers rent housing here and stay temporarily, diluting the aging structure of the peripheral population. In addition, there are many left-behind children in the peripheral areas, and the population is young, so the ratio of young to old in the peripheral areas, such as Yantan, Donggang, and Yanchang clusters of Chengguan District, Anning Fort and Shajingyi Street of Anning District, Pengjiaping and Gongjiawan Streets of Qilihe District, and Chenping Street of Xigu District, is even lower than that in the core and central districts.

4.2.2. Gender structure of the population in the living area

The sex ratio usually varies around 100%, when the ratio is greater than 100%, it means that the male population is larger than the female population, and when the ratio is less than 100%, the opposite is also true. Along with the expansion of 5-minute, 10-minute, and 15-minute living circles, the sex ratio has evolved from a fragmented characteristic to a concentrated and piecemeal spatial pattern. The sex ratio is high in peripheral urban areas and low in inner-core urban areas, with high values nested in higher-value areas and low values nested in lower-value areas, and with high and low values “next to each other” in some areas. The sex ratio of a population usually depends on factors such as differences in the level of mortality between men and women, differences in the level of migration between men and women, the age structure of the population, and the sex ratio at birth. The areas with high sex ratios in the living area are located in Qingbaishi Street in Chengguan District, Yanjiaping and Xihu Streets in Qilihe District, and Xilu Street in Anning District, which are net population inflow areas [27]. Traditional agricultural society, “male farming, female weaving” family life state by the factory machine mass production gradually disintegrated, the male of the vernacular society from the family to enter the factory, and gradually formed the “woman in charge of the family, the man outside the home” mode, men go out to work temporarily living in the city! This affects the gender structure of the native population, resulting in a large number of mobile males and a high sex ratio in the peripheral areas.

The high value areas and high value areas of the life circle gender comparison are embedded in the distribution, spatially implemented in Chengguan District Yancang Road Street, Qilihe District Xiyuan Street, Anning District Yintan Road, Kongjiaya Street, Xigu District Chenping

Street, these areas also belong to the hotspot of the net migration of the population into the area, the complete infrastructure construction and good employment conditions attracted a large number of laborers, especially men in addition to the gathering of migrant workers to broaden family economic income and indirectly also change the local population gender structure. These areas are also hotspots for net migration of population, where well-developed infrastructure and good employment conditions have attracted many laborers, especially men, to gather in addition to migrant workers, broadening the economic income of their families, and indirectly changing the gender structure of the local population.

Circle of life gender ratio of the median and lower value of the regional distribution of a wide area, the median area is distributed in the Chengguan District Yantan, Yantan area, Anning District, Anning Fort Street, the northern part of the street, Kongjiaya Street, southeast of the part of the area, the Qilihe District, Tumendun, Pengjiaping Street, Xigu District, Xiliugou, the Pioneer Road Street, the lower value of the area is mostly in the heart of the city's urban development and the central area, such areas are well equipped with senior living facilities to attract a lot of elderly people! Gathering of the elderly, affected by the physiological structure of men and women, female life expectancy is higher than that of men, the elderly among the female bias, coupled with the local female groups affected by traditional attitudes, family livelihood options in favor of staying home to take care of the elderly and children, focusing on the spatial manifestation of the proportion of females in these areas is relatively high, the gender ratio of the value of the lower.

Areas with low sex ratios in the living area are embedded in areas with lower values, and the lower-value areas are specifically located in Baiyin Road and Weiyuan Road streets in Chengguan District, and in parts of the southern part of Peili Street and Anningbao Street in Anning District, and are distributed in close proximity to the higher-value areas. The streets of Baiyin Road and Weiyuan Road belong to the hotspot of net outflow of population, and males account for a large proportion of the net outflow of population, resulting in a high number of male and female students and a low sex ratio. On the other hand, some areas of Peili Street and Anningbao Street have a large number of colleges and universities, resulting in an increase in the number of foreign students, and a high number of females in the ratio of males to females in the colleges and universities, which has an impact on the gender structure of the local population.

4.3. Characterization of the distribution of population circles and the distribution of the population in the sample zones

According to the type of urban spatial location and hierarchical sequence, the city is divided into central, edge and peripheral districts from the inside out, and the number of population and living circles are integrated into the circle division, and it is found that (Table 2) the population distribution presents the characteristics of "circle-differentiation", and the central district is higher than the edge and peripheral districts in terms of the number of living circles, the number of population, and the number of people with different characteristics. Both the number of living circles and the total population and different characteristics are higher in the central area than in the marginal and peripheral areas, showing the characteristics of circle differentiation decreasing from the center to the periphery. The ratio of the total population of the central district, edge district and peripheral district is 1:0.74:0.24, and the ratio of the number of living circles is 1:0.72:0.32. The central district is a magnetic pole for the gathering of resource elements, with a strong siphon force of the population and the prosperity of the region, shielding and taking away the space for the development of the edge and peripheral districts, forming a clear difference in the population size, population density and heterogeneity of the population (hierarchical boundaries, class structure) with the peripheral districts. It is a

clear difference in population size, population density, and population heterogeneity (hierarchical boundaries and class structure).

Table 2 Statistical data sheet on the distribution of population circles

	Number of life circles(number)			total population (persons)	0-14 years (persons)	Older than 65 years of age (persons)	Male population (persons)	Female population (persons)
	5min	10min	15min					
central district	248	180	75	1387233	192750	173847	705028	681818
interface	186	126	50	1025414	134694	100371	531923	491143
periphery	69	54	16	332618	55207	48342	172620	158725

The peaks and valleys of the total population and the population of different characteristics of the sample zone alternate, showing the spatial distribution characteristics of “sparse in the northwest and dense in the southeast” (Figure 7), and the population increases steeply at 17,000m from the starting point, with two larger peaks of the total population appearing in Xiguanshizi and Nanguanshizi, Gongxingdun street area, and the second level of wave peaks appeared in the Qilihe district along the West Station street. Children's population and the elderly population in the sample strip, the characteristics of the population size change with the total population superimposed quality is similar, but different from the total population, the children's population in the southeast of the dense area of the peak appeared four times, corresponding to the spatial location in the “Xiguan-Nanguan- Guangwumen Gongxingdun” area, while the elderly population is in the “Xiguan- Nanguan- Guangwumen Gongxingdun” area. “The elderly population forms a huge valley between the two peaks in the southeastern intensive area, and the population profile of the male sample zone is basically similar to that of the female, which confirms that the sex ratio of the living area of Lanzhou City mostly changes around 100%.

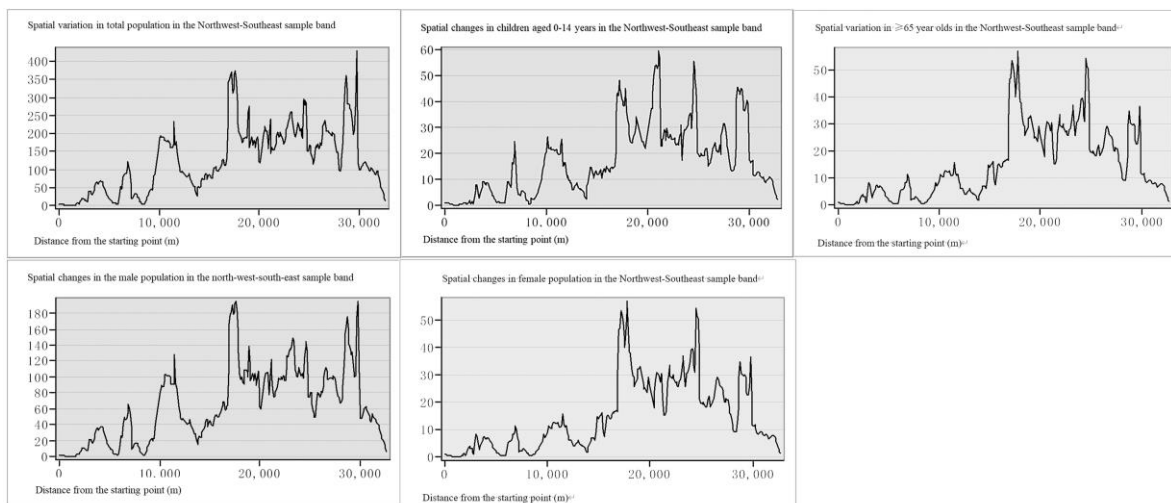


Figure 7 Changes in the spatial distribution of the total population and the population with different characteristics in the population sample strip

5. Reach a verdict

(1) Within the 5-min, 10-min, and 15-min living area, the total population and the population with different characteristics have similar ratios in terms of population mean and population standard deviation, roughly showing a quantitative relationship of 1:4:10 and 1:3.5:8, and the male population has the same proportionality to the female population in terms of the number

of population means and standard deviations of the population, while the proportion of children's population mean is slightly lower than that of the elderly population, and the proportion of standard deviations of the population is slightly higher than that of the elderly population. The ratio is slightly higher than that of the elderly population.

(2) Along with the expansion of 5min, 10min and 15min living circles, the ratio of the elderly to the young has evolved from a fragmented feature to a concentrated and piecemeal spatial pattern. The core area of urban development has a high level of old/young ratio and the peripheral area has a low level of old/young ratio, presenting a "higher-medium-lower" circle winding structure; along with the expansion of the scope of the 5min, 10min and 15min living circle, the sex ratio has evolved from a fragmented feature to a concentrated and patchy spatial pattern of distribution, and the sex ratio has evolved from a fragmented feature to a concentrated and patchy spatial pattern of distribution. Along with the expansion of the 5min, 10min and 15min living circle, the sex ratio has evolved from a fragmented character to a centralized and piecemeal spatial distribution, with a high value of the sex ratio of the population in the three levels of the living circle in the peripheral areas of the city and a low value in the inner-core areas of the city, with the high-value areas nested in the higher-value areas and low-value areas nested in the lower-value areas, and there is the phenomenon of the high-value and low-value being "adjacent to each other at the poles" in some areas.

(3) The ratio of the total population in the central, peripheral and outlying areas is 1:0.74:0.24, and the ratio of the number of living circles is 1:0.72:0.32. Population distribution shows the characteristic of "circle-differentiation", with the central area having a higher population than the peripheral and outlying areas in terms of both the number of living circles and the total population, as well as the number of people with different characteristics. The center area has a higher number of living circles, total population, and population with different characteristics than the edge area and peripheral area, showing a circle differentiation decreasing from the center to the periphery. The peaks and valleys of the total population and the population with different characteristics of the sample zone alternate, showing a spatial distribution characteristic of "sparse in the northwest and dense in the southeast".

References

- [1] Wang Yanhui. Research on the Current Problems and Countermeasures of Closed Residential Areas in Chinese Cities [J]. *Modern Urban Research*, 2010, 25(03): 85-90.
- [2] Chai Yanwei, Li Chunjiang. Urban Living Circle Planning: From Research to Practice [J]. *City Planning Review*, 2019, 43(05): 9-16+60.
- [3] Zhou Jie. Analysis of the Factors of Subjective Dominance in Urban Planning [D]. Zhejiang University, 2006.
- [4] Yu Xiao, Wang Qihui. Research on the Impact of Urban Population Agglomeration on Workers' Employment Satisfaction [J/OL]. *Northwest Population*: 1-15 [2023-09-08].
- [5] Wang Can, Xu Junping, Zhang Yibo. Research on the Spatial Layout and Accessibility of Medical Facilities Based on the Improved Ga2SFCA Algorithm: A Case Study of Xiamen City [J]. *Architecture & Culture*, 2022(06): 101-104. DOI: 10.19875/j.cnki.jzywh.2022.06.033.
- [6] Wang Qingqing. Research on the Supply and Demand Matching of Public Service Facilities in Public Rental Housing Communities in Chongqing [D]. Chongqing University, 2022. DOI: 10.27670/d.cnki.gcqdu.2022.000609.
- [7] Wang Zhen, Zhang Min. The Impact of Urban Community Renewal on Residents' Subjective Well-being: An Empirical Study Based on Typical Communities in Nanjing [J/OL]. *Tropical Geography*: 1-14 [2023-09-08]. DOI: 10.13284/j.cnki.rddl.003736.
- [8] Wang Lucang, Chang Fei. Research on the Relationship between Work and Residence in the Main Urban Area of Lanzhou Based on Multi-source Data [J]. *Human Geography*, 2020, 35(03): 65-75. DOI: 10.13959/j.issn.1003-2398.2020.03.008.

- [9] Zhang Jingxiang, Huang Longyan. Transformation of New Town Planning and Construction in China in the Era of Urbanization 2.0 [J]. *Shanghai Urban Planning*, 2022(02): 54-58.
- [10] Zhu Li. On the Urban Adaptation of the Migrant Worker Class [J]. *Journal of Jianghai*, 2002(06): 82-88+206.
- [11] Yan Wentao, Li Zihao. Research on the Resilience Mechanism of Urban Spatial Structure from the Perspective of Risk Disturbance: Theoretical Framework and Empirical Methods [J]. *International Urban Planning*, 2023, 38(04): 1-10. DOI: 10.19830/j.upi.2023.269.
- [12] Xiao Zuopeng, Chai Yanwei, Zhang Yan. Review of Research and Planning Practice Progress on Urban Living Circle Planning at Home and Abroad [J]. *Planners*, 2014, 30(10): 89-95.
- [13] Cheng Rong. Spatial Governance Countermeasures for 15-Minute Community Living Circles [J]. *Planners*, 2018, 34(05): 115-121.
- [14] Li Wenbin, Chen Hao. Analysis of the Connotation of Industry-City Integration and Planning Suggestions [J]. *Urban Planning Forum*, 2012(S1): 99-103.
- [15] Zhou Biru. Research on the Optimization of Public Service Facility Layout in Urban Communities Based on the Living Circle [D]. Suzhou University of Science and Technology, 2018.
- [16] Shen Yuhui, Tong Ziyu. Research on the Evaluation Method of Community Living Circle Convenience from a Human-scale Perspective [J]. *Southern Architecture*, 2022(07): 72-80.
- [17] Li Yanxi, Chai Yanwei, Tana. From Disaster Prevention Life Circle to Safety Life Circle: Japanese Experience and Chinese Reflections [J]. *International Urban Planning*, 2022, 37(05): 113-120. DOI: 10.19830/j.upi.2020.365.
- [18] Zhao Baojing, Xi Wenqin, Wu Qiuqing, et al. Shaping Resilient Community Commons: Planning Thoughts and Strategies on Life Circles [J]. *Shanghai Urban Planning*, 2020(02): 14-19.
- [19] Zou Bing. Transition from Incremental Planning to Stock Planning: Theoretical Analysis and Practical Responses [J]. *Urban Planning Forum*, 2015(05): 12-19. DOI: 10.16361/j.upf.201505001.
- [20] Chang Fei, Wang Lucang, Ma Yue, et al. Is There a Match between Urban Public Service Institutions and Population? An Evaluation Based on Community Life Circles [J]. *Progress in Geography*, 2021, 40(04): 607-619.
- [21] Zhou Yixing, Meng Yanchun. Suburbanization Trends in Large Chinese Cities [J]. *Urban Planning Forum*, 1998(03): 22-27+64.
- [22] Rao Chuankun, Cai Yixiang. Spatial Expansion Characteristics of Large-scale Retail Commercial Facilities in Hangzhou City [J]. *Economic Geography*, 2016, 36(02): 117-124. DOI: 10.15957 /j.cnki.jjdl.2016.02.016.
- [23] Yang Wuyang. The Past, Present and Future of Retail and Service Centers and Outlets in Beijing [J]. *Acta Geographica Sinica*, 1994(01): 9-17.
- [24] Han Fei, Luo Renchao. Research on the Supply and Demand Matching of Home-based Elderly Care Services in Urban Communities Based on Accessibility Measurement: A Case Study of Nanjing [J]. *Economic Geography*, 2020, 40(09): 91-101. DOI: 10.15957/j.cnki.jjdl.2020.09.010.