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Spatial Patterns of Public Service Facilities and Planning Responses in a Valley City: A Case Study of Lanzhou, China

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ABSTRACT

Public service facilities constitute key spatial underpinnings for optimizing territorial resource allocation and securing residents' daily well-being. As a typical valley-constrained city, Lanzhou faces pronounced geographical bottlenecks alongside stark development gaps between its central urban core and peripheral districts and counties. Drawing on 28 686 2025 points-of-interest (POI) records of public service amenities, this study reclassifies facilities into six groups: elderly care, healthcare, public transport, basic education, cultural-sports services, and commercial services. We apply kernel density estimation, standard deviational ellipse analysis, correlation analysis, and the CRITIC objective-weighting approach to unpack spatial-clustering characteristics, directional expansion trends, inter-facility correlations, and the composite distribution of these amenities. Results indicate a strong central-clustering tendency across Lanzhou's public-service system: the interconnected Chengguan-Qilihe-Anning zone functions as the dominant high-density hub, while facility availability diminishes outwards toward peripheral counties. Healthcare, commercial, and cultural-sports services demonstrate high centrality; basic-education and public-transport amenities achieve wider geographical reach; yet elderly-care provision remains spatially limited. Collectively, all six facility types stretch along a northwest–southeast axis and feature robust spatial co-occurrence, with elderly-care services representing the main exception and showing partial spatial decoupling from other everyday-life amenities. The composite assessment confirms a distinct "core-concentration–peripheral-decline" gradient. In response, this paper puts forward place-specific planning strategies: upgrading existing facilities within central urban districts, filling gaps in basic-service provision across peripheral counties, aligning public-service construction with residential-industrial growth in new towns and development zones, and enhancing synergies between public-service nodes and major transport corridors.

KEYWORDS

Public Service Facilities; POI Data; Spatial Pattern; Territorial Spatial Planning; Lanzhou

1. INTRODUCTION

Public service facilities are essential spatial carriers that support residents' daily lives and the normal functioning of cities. As territorial spatial planning has gradually shifted from land-use control toward spatial governance and quality improvement, the focus of public service provision has expanded from the quantity and construction scale of facilities to basic service provision, spatial equity, functional integration, and coordinated provision across different facility levels. The Lanzhou Territorial Spatial Master Plan (2021–2035) proposes the establishment of a balanced and inclusive public service system and the development of 15-minute community life circles[1], while emphasizing the coordinated provision of education, healthcare, elderly care, cultural, and sports facilities. Against the backdrop of continuing adjustments in urban spatial structure, identifying the existing spatial

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pattern and regional disparities of public service facilities therefore constitutes an important basis for optimizing territorial spatial resource allocation[2].

Existing research on public service facilities has evolved from early descriptions of facility quantity and location toward analyses of spatial clustering, accessibility, service equity, and supply–demand matching[3]. With advances in geographic information technologies and Internet-based location data, POI data have been widely applied to urban functional identification and public service facility research because of their relatively high positional accuracy and fine-grained facility classification[4]. Some studies have examined the overall spatial structure of urban public service resources, using methods such as kernel density estimation and spatial autocorrelation to reveal facility clusters and differences between central and peripheral areas. Others have incorporated population, road networks, and residential space to assess the accessibility and service coverage of specific facilities such as healthcare, education, and cultural services[5][6]. In recent years, increasing attention has also been paid to facility equity for specific population groups, including older adults, children, and low-income residents. These studies indicate that public service facilities are not distributed homogeneously; rather, their spatial patterns are often closely associated with population distribution, development intensity, transport conditions, and the broader urban spatial structure[7].

Compared with large plain cities, Lanzhou is subject to distinctive spatial constraints. Shaped by the Yellow River valley and the mountains to the north and south, the central urban area has long developed in a linear form along the valley, producing marked spatial differentiation among established districts, new urban areas, and peripheral counties[8]. Existing studies on Lanzhou have examined the needs of older adults and children, accessibility to public service facilities, and supply–demand relationships. However, they have largely focused on the central urban area, specific population groups, or selected facility types. Further investigation is therefore needed to compare the spatial clustering patterns, inter-facility relationships, and integrated service structure of different public service facilities at the municipal scale.

Accordingly, this study uses POI data as the primary dataset for identifying the spatial structure of public service facilities in Lanzhou and addresses three questions. First, what clustering, expansion, and directional characteristics do different types of public service facilities exhibit at the municipal scale? Second, do different facilities share consistent spatial organizational relationships, and does the overall level of service provision display a pronounced core–periphery gradient? Third, given Lanzhou's valley-constrained and polycentric-grouped urban structure, how should existing spatial disparities in facility provision be translated into differentiated requirements for territorial spatial planning? Through these analyses, the study seeks to move beyond spatial pattern identification toward the interpretation of planning issues and corresponding spatial responses.

2. STUDY AREA, DATA, AND METHODS

2.1. Study Area

Lanzhou is located in central Gansu Province and is an important regional center in northwestern China. The municipality comprises five urban districts—Chengguan, Qilihe, Xigu, Anning, and Honggu—and three counties—Yongdeng, Yuzhong, and Gaolan. At the end of 2025, Lanzhou had a permanent population of 4.4514 million. Among its districts and counties, Chengguan District had the largest permanent population, whereas Gaolan County had the smallest.

Unlike typical plain cities, Lanzhou's central urban area is constrained by a distinctive topography characterized by "two mountains flanking one river." Urban construction space is concentrated along the Yellow River valley and forms a linear and clustered development pattern along major transport corridors. The central urban area accommodates high concentrations of population, employment, and public services, whereas peripheral counties, new towns, and development zones differ in both development intensity and facility foundations. Consequently, the spatial distribution of public

service facilities in Lanzhou is shaped not only by population and the concentration of urban functions, but also by topographic conditions, transport corridors, and connections among urban clusters. These characteristics provide the key regional context for analyzing spatial disparities in public service provision.

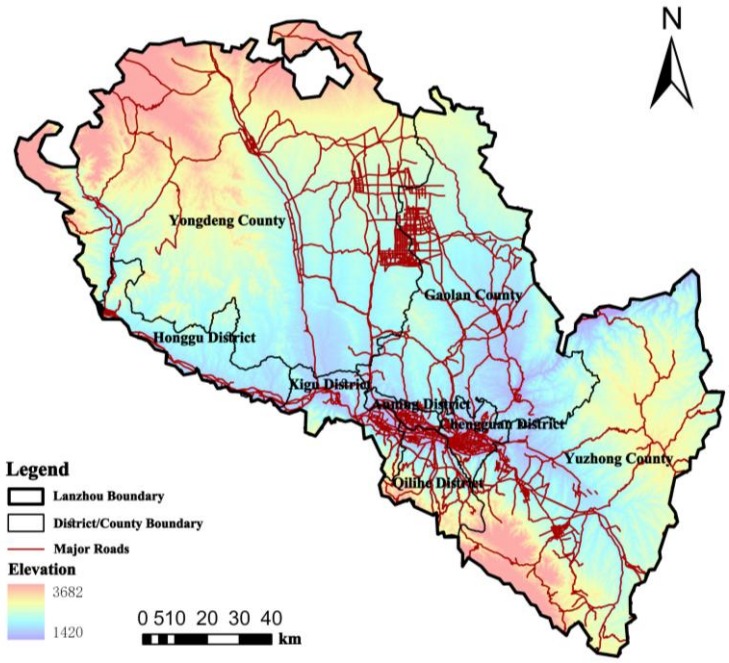


Figure 1. Location of Lanzhou

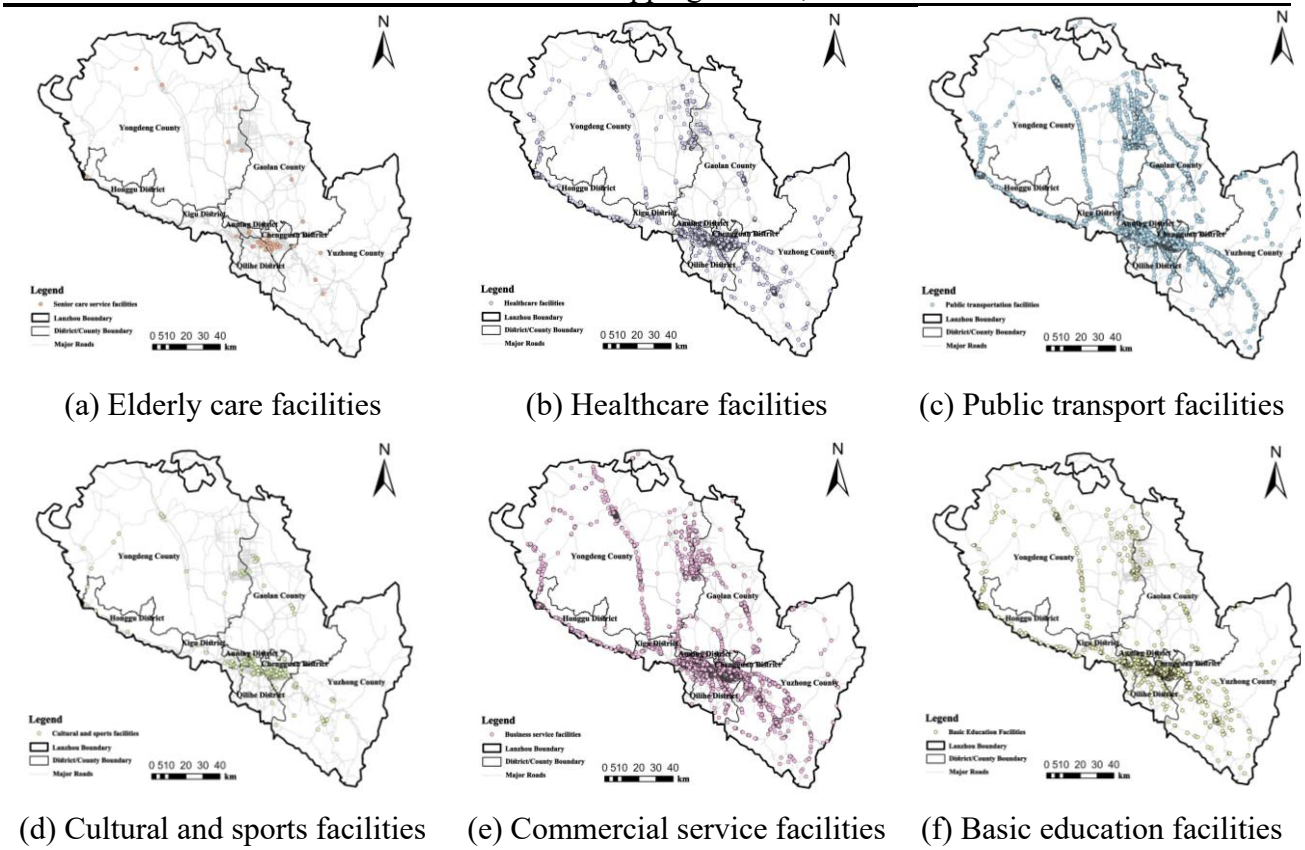
2.2. Data Sources and Facility Classification

The study uses three main types of data: POI data, basic geographic data, and statistical data. After data cleaning, 28,686 valid POI records were retained. Basic geographic data mainly include vector data for administrative boundaries and road networks, while population and socioeconomic background information were primarily obtained from the Lanzhou Statistical Yearbook.

Facility classification was based on the Standard for Urban Residential Area Planning and Design (GB 50180–2018) and relevant planning requirements for community life circles. The original Amap POI categories were reclassified into six groups: elderly care, healthcare, public transport, basic education, cultural and sports services, and commercial services[9]. The final dataset contains 55 elderly care facilities, 4,935 healthcare facilities, 6,265 public transport facilities, 1,181 basic education facilities, 250 cultural and sports facilities, and 16,000 commercial service facilities. Although commercial services do not entirely fall within the category of nonprofit basic public services, they are directly related to residents' daily consumption and the functioning of community life circles. They were therefore included primarily to assess the spatial co-location between daily-life service functions and public service facilities such as education, healthcare, and elderly care.

Table 1 Classification and Number of Public Service Facilities

Primary category	Secondary types	Total
Elderly care	Nursing homes, elderly care institutions, community elderly care centers, elderly care service stations, etc.	55
Healthcare	General hospitals, specialized hospitals, community health service institutions, clinics, pharmacies, etc.	4935
Public transport	Bus stops, passenger transport stations, public parking facilities, etc.	6265
Basic education	Kindergartens, primary schools, secondary schools	1181
Cultural and sports services	Cultural centers, cultural activity centers, youth activity facilities, sports venues, etc.	250
Commercial services	Supermarkets, convenience stores, farmers' markets, restaurants, shopping centers, etc.	16000



(a) Elderly care facilities (b) Healthcare facilities (c) Public transport facilities

(d) Cultural and sports facilities (e) Commercial service facilities (f) Basic education facilities

Figure 2. POI Distribution of Six Types of Public Service Facilities in Lanzhou

2.3. Methods

To identify the spatial organization of different public service facilities, this study integrates kernel density estimation, standard deviational ellipse analysis, spatial correlation analysis, and CRITIC objective weighting. Kernel density estimation converts discrete POIs into continuous density surfaces. By comparing the locations, extents, and spatial continuity of high-density areas for the six facility types, it reveals differences in clustering among the central urban area, county-seat nodes, and peripheral areas. The resulting density surfaces indicate relative spatial concentration rather than actual service capacity or residents' accessibility. Standard deviational ellipse analysis is used to characterize the spatial center, dispersion, and dominant orientation of each facility type. Comparing ellipse orientation, extent, and overlap helps determine whether different facilities are constrained by similar urban spatial structures. Spatial correlation analysis compares the density patterns of different facilities across a common spatial unit to identify the degree of co-location or differentiation among

facility types. Correlation coefficients represent spatial consistency only and do not imply direct causal relationships between facilities[10].

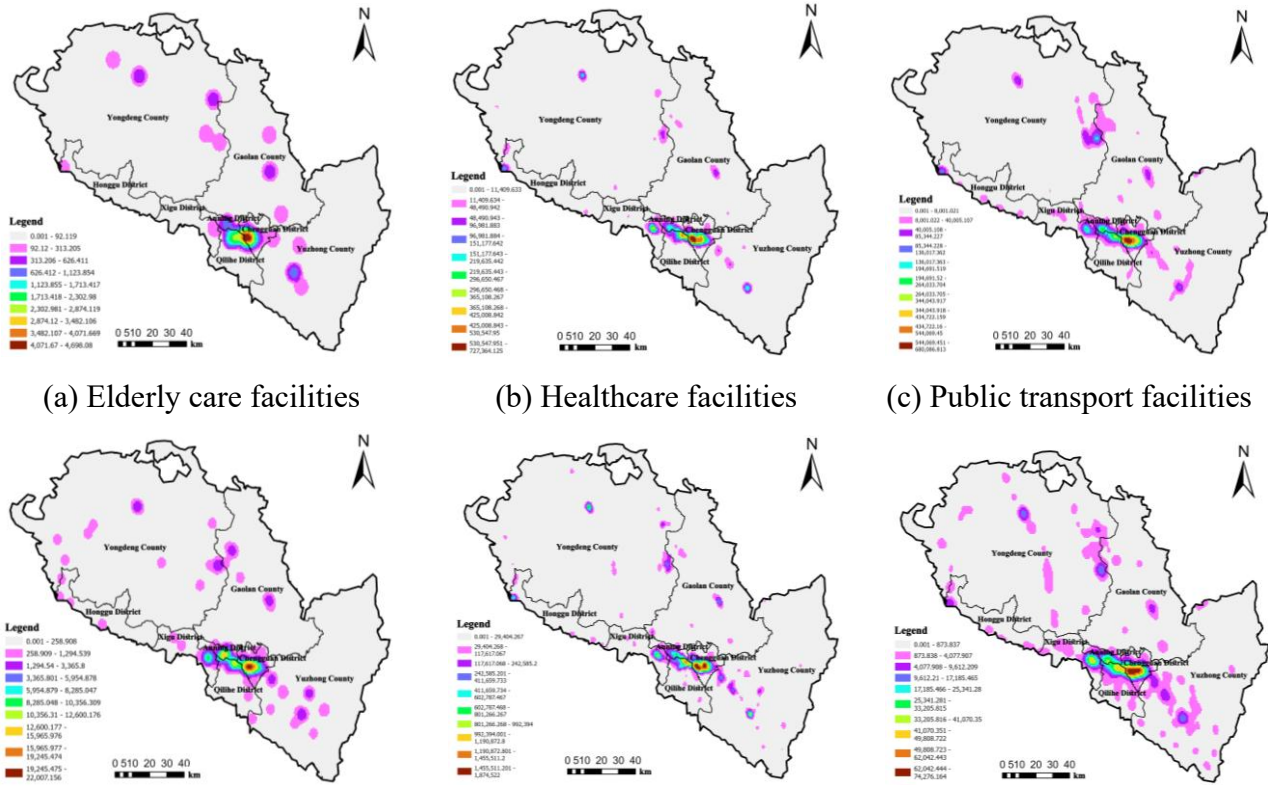
Building on the analysis of individual facility patterns and inter-facility relationships, the CRITIC method is used for objective weighting, and the standardized indicators of the six facility types are combined through weighted overlay to identify the integrated spatial pattern generated by multiple types of public service facilities. CRITIC determines indicator weights by simultaneously considering the internal variability of each indicator and the degree of information overlap among indicators[11]. An indicator receives a relatively higher weight when it exhibits greater spatial variation and lower correlation with other indicators, thereby contributing more independent information.

3. SPATIAL PATTERNS OF PUBLIC SERVICE FACILITIES IN LANZHOU

3.1. Overall Distribution Exhibits Pronounced Central Clustering

Public service facilities in Lanzhou are not distributed uniformly. High-density areas for most of the six facility types are concentrated in the contiguous built-up areas spanning Chengguan, Qilihe, and Anning districts. Peripheral districts and counties form smaller secondary clusters, primarily around county seats and local urban nodes. Facility density generally decreases with increasing distance from the central urban area. This spatial gradient is highly consistent with Lanzhou's long-standing concentration of population, employment, and urban functions in the traditional central city.

Although central clustering is a common feature of all six facility types, substantial differences remain in the continuity of high-density areas and the extent of outward expansion. Healthcare, commercial, and cultural and sports facilities are more strongly dependent on the central urban area; public transport and basic education facilities show more evident nodal diffusion; and elderly care facilities display a comparatively dispersed supply pattern because of their limited number.



(a) Elderly care facilities (b) Healthcare facilities (c) Public transport facilities

(d) Cultural and sports facilities (e) Commercial service facilities (f) Basic education facilities

Figure 3. Kernel Density of Public Service Facilities in Lanzhou

3.2. Healthcare, Commercial, and Cultural–Sports Facilities Exhibit Strong Centrality

High-density healthcare facilities are concentrated mainly in the central parts of Chengguan, Anning, and Qilihe districts. Xigu District forms a secondary cluster to some extent, whereas facility densities are relatively low in peripheral areas such as Yongdeng, Gaolan, Yuzhong, and Honggu.

Commercial services exhibit an even more pronounced pattern of central clustering, with high-density areas concentrated where population and activity intensity are greatest in the central urban area. Spatially, high-density commercial areas overlap substantially with healthcare and other comprehensive service facilities, indicating the formation of integrated service clusters in the traditional central city through the combined effects of employment, consumption, healthcare, and public activities.

Cultural and sports facilities are fewer in number than healthcare and commercial facilities, and their high-density areas are more spatially concentrated, mainly within the central urban area. Outside the center, continuous high-value areas are limited, apart from a small number of county-seat nodes. This suggests that higher-order and less frequently used cultural and sports resources are more strongly dependent on the central urban area[12].

Healthcare, commercial, and cultural–sports facilities therefore jointly constitute a distinct concentration of center-oriented service functions in Lanzhou, reflecting the close spatial relationship between public service functions and areas of high-intensity urban development.

3.3. Public Transport and Education Facilities Form Broader Node–Network Patterns

Compared with commercial and cultural–sports facilities, public transport and basic education facilities have broader spatial coverage.

Public transport facilities form continuous high-density areas in the central urban area, with particularly evident concentrations around Lanzhou Railway Station, Lanzhou West Railway Station, and surrounding transport nodes. Peripheral districts and counties also contain localized clusters around major towns and transport nodes. The analysis shows that public transport facility density is higher in the central urban area and gradually declines toward suburban areas. This pattern indicates that, in addition to population density, transport service facilities have a network-based locational logic associated with transport corridors and nodes.

Basic education facilities have relatively broad spatial coverage among the six facility types. In addition to the central urban area, localized concentrations are found in the county seats of Yuzhong, Yongdeng, and Gaolan, as well as in Xigu. Compared with commercial and cultural–sports facilities, education facilities have a stronger basic public service function and need to cover a wider range of residential and urbanized spaces. They therefore exhibit a relatively dispersed spatial form, creating a node–network service pattern distinct from center-oriented facility types.

3.4. Elderly Care Facilities Are Few in Number and Spatially Dispersed

Only 55 elderly care facilities were identified, making this the least numerous of the six facility categories. High-density areas are concentrated mainly in the adjoining parts of Chengguan and Qilihe districts, while continuous coverage is largely absent outside the central urban area, indicating a relatively uneven spatial distribution.

A small number of facilities does not necessarily imply inadequate elderly care capacity, because institutions may differ substantially in size, bed capacity, and service level. Nevertheless, POI coverage indicates that identifiable elderly care facilities are relatively limited in peripheral areas. This suggests that planning assessments for elderly care should not simply follow the locational logic

of commercial or healthcare facilities, which tend to cluster with population and urban centers. Instead, they should be combined with information on the spatial distribution of older residents, community-based care needs, and the actual service capacity of individual institutions.

4. SPATIAL ASSOCIATIONS AND INTEGRATED SERVICE PATTERN OF PUBLIC SERVICE FACILITIES

4.1. The Six Facility Types Share a Consistent Overall Direction of Spatial Expansion

The results show that all six types of public service facilities extend predominantly along a northwest–southeast axis. Their spatial centers are concentrated in and around Chengguan District, and multiple standard deviational ellipses overlap substantially in the central urban area. This indicates that, despite differences in quantity and coverage, the macro-scale distributions of the different facility types remain constrained by a similar urban spatial framework.

Lanzhou's central urban area has long developed along the Yellow River valley and major transport corridors. Where limited developable land simultaneously accommodates residential, employment, commercial, and public service functions, different facilities tend to form similar spatial centers and expansion axes. The relatively large standard deviational ellipse of basic education facilities indicates a greater degree of extension toward peripheral counties and urban clusters, whereas the more compact ellipse for cultural and sports facilities further reflects the stronger dependence of higher-order public cultural resources on the central urban area.

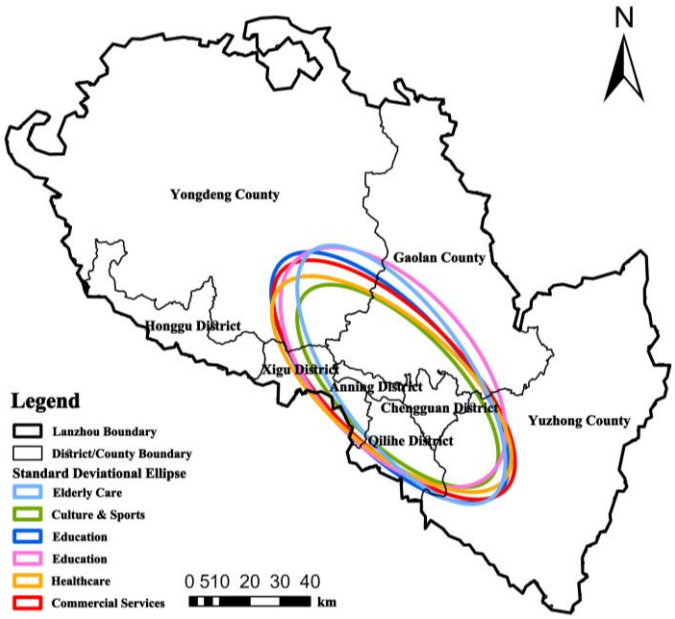


Figure 4. Standard Deviational Ellipse Analysis of Public Service Facilities in Lanzhou

4.2. Inter-Facility Relationships Show "Integrated-Service Co-location–Specialized-Facility Differentiation"

Correlation analysis indicates generally strong positive relationships among the six facility types, although the degree of spatial consistency varies across facility pairs. The correlation coefficient between commercial services and healthcare facilities reaches 0.97878, that between healthcare and public transport is 0.96203, whereas the coefficient between elderly care and commercial services is only 0.74430, the lowest among all facility pairs.

Frequently used urban functions such as commerce, healthcare, and transport tend to co-locate in areas with high population activity, favorable transport conditions, and dense built environments. Their strong correlations therefore reflect the spatial superimposition of multiple service functions in the traditional central city. By contrast, the weaker association between elderly care and commercial services suggests that specialized service facilities do not entirely follow the locational logic of consumption and employment centers. Their spatial organization is more strongly influenced by residential environments, community coverage, and the needs of specific population groups. As a result, Lanzhou's public service system exhibits overall co-location while retaining a degree of functional differentiation.

Table 2 Spatial Correlation Matrix of Public Service Facilities in Lanzhou

Public service facilities	Elderly care	Healthcare	Public transport	Cultural and sports services	Commercial services	Basic education
Elderly care	1	0.78208	0.78703	0.78487	0.74430	0.81537
Healthcare	0.78208	1	0.96203	0.90982	0.97878	0.93609
Public transport	0.78703	0.96203	1	0.93810	0.94946	0.94935
Cultural and sports services	0.78487	0.90982	0.93810	1	0.90000	0.95251
Commercial services	0.74430	0.97878	0.94946	0.90000	1	0.92837
Basic education	0.81537	0.93609	0.94935	0.95251	0.92837	1

4.3. The Integrated Service Pattern Exhibits a Distinct Core–Periphery Gradient

According to the CRITIC weighting results, elderly care, cultural and sports services, and basic education receive relatively high weights. These weights reflect the dispersion and independent information content of different indicators in the current spatial dataset; they do not represent the planning importance of each facility type within the public service system. The standardized results for the six facility types were subsequently combined through weighted overlay to generate an integrated evaluation surface for public service facilities in Lanzhou.

The integrated results show that high-value areas are concentrated mainly in the contiguous built-up areas spanning Chengguan, Qilihe, and Anning districts. Areas around central-city streets such as Zhangye Road, Guangwumen, and Jianlan Road exhibit relatively high composite values, which gradually decline from the urban core toward peripheral areas.

The integrated evaluation is highly consistent with the analyses of individual facility types. This indicates that Lanzhou has not developed several independent public service centers of comparable hierarchy. Instead, multiple service functions continue to overlap in the traditional central urban area, while peripheral counties rely more heavily on county seats and local urban nodes to maintain basic service provision. From the perspective of the municipal territorial spatial structure, the existing pattern forms a hierarchy of "integrated concentration in the central urban area–support by peripheral urban nodes–low-density coverage in county hinterlands." However, because the evaluation does not incorporate hospital grades, school enrollment capacity, elderly care beds, or actual service capacities, high composite values indicate the relative spatial concentration of facility supply rather than public service quality or residents' living standards.

Table 3 CRITIC Weights of Public Service Facility Types in Lanzhou

Public service facilities	Elderly care	Healthcare	Public transport	Cultural and sports services	Commercial services	Basic education
Weight	0.338	0.106	0.107	0.154	0.144	0.151

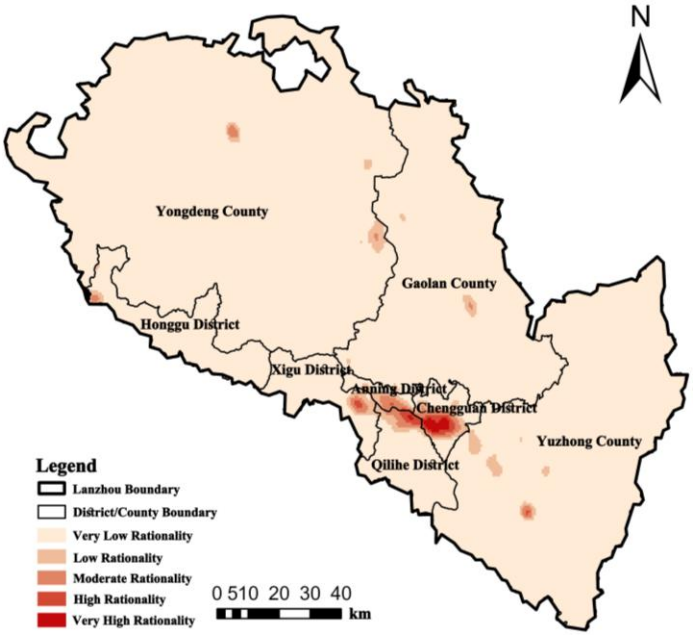


Figure 5. Integrated Evaluation of Public Service Facilities in Lanzhou

5. DIFFERENTIATED PLANNING RESPONSES UNDER THE TERRITORIAL SPATIAL PLANNING FRAMEWORK

The spatial analysis indicates that the principal issue facing Lanzhou's public service facilities is not simply an "overall shortage in quantity," but rather pronounced differences among areas in the degree of facility concentration, service composition, and spatial coverage. Planning responses should therefore avoid a uniform strategy of increasing facility numbers and instead adopt differentiated provision strategies for the central urban area, peripheral counties, new towns and development zones, and valley transport corridors[13][14].

5.1. Central Urban Area: From Quantitative Expansion to Quality Improvement and Functional Integration of Existing Facilities

The adjoining areas of Chengguan, Qilihe, and Anning have already formed Lanzhou's most prominent core of public service facilities, where healthcare, commercial, transport, and cultural–sports functions are highly concentrated within limited developable land. Continued reliance on quantitative facility growth would be unlikely to improve service efficiency substantially and could further increase pressure on land capacity in the central city. Planning priorities should therefore shift gradually from incremental construction toward the multifunctional use and quality enhancement of existing public resources[15].

Urban renewal can activate underused public buildings and existing spaces, enabling community education, healthcare, elderly care, cultural activities, and other functions to be organized in an integrated manner within the same life circle. Time-sharing of school sports grounds, cultural venues, and community public spaces can further extend the effective service reach of existing facilities. In this way, public service provision in the central urban area can shift from an emphasis on "sufficient quantity" toward improved facility usability, sharing, and spatial efficiency.

5.2. Peripheral Counties: From Average Provision to Safeguarding Minimum Standards of Basic Public Services

Facility densities in peripheral counties such as Yongdeng, Gaolan, and Yuzhong are considerably lower than those in the traditional central urban area. However, these counties also differ substantially in population size, settlement density, and spatial distribution. Using central-city facility density directly as an evaluation benchmark may therefore conflate low population density with inadequate service provision. A more appropriate planning approach is to establish differentiated levels of provision according to facility hierarchy and service attributes[16].

Facilities associated with basic livelihoods, including education, primary healthcare, and elderly care, should achieve as broad a coverage as possible through a clearly structured service hierarchy of county seat–key town–community (village)[17]. By contrast, cultural and sports facilities and higher-order healthcare services may be moderately concentrated in county seats and key towns. Strengthening the service capacity of such nodes can avoid the inefficiency associated with evenly dispersing higher-level resources across low-density areas. The currently limited peripheral coverage of elderly care facilities should also be assessed alongside the spatial distribution of older residents to identify genuine service gaps, thereby forming a county-level model characterized by "broad coverage of basic services and nodal concentration of higher-order facilities."

5.3. New Towns and Development Zones: Avoiding "Development First, Public Services Later"

Lanzhou's urban space is expanding from the traditional central city toward peripheral clusters, new towns, and development zones. In these expansion areas, public service provision should avoid the common development trajectory in which residential and industrial construction precedes the provision of public services.

Public service facilities in new towns and development zones should be provided broadly in step with population inflow, residential development, and industrial layout. Basic education, community healthcare, cultural and sports services, and elderly care should be introduced from the early stages of development according to phased population size, while sufficient spatial flexibility should be reserved for future population growth. For new towns that perform regional functions, education, healthcare, and cultural facilities of an appropriate hierarchy should be provided in accordance with their planning roles, enabling them to evolve from single-purpose residential or industrial clusters into relatively independent comprehensive service nodes and reducing long-term dependence on the traditional central urban area.

5.4. Valley Urban Space: Strengthening Coordination between Transport Corridors and Public Service Nodes

The common expansion axis revealed by the standard deviational ellipses indicates a strong relationship between Lanzhou's public service facilities and its linear valley morphology. The mountains to the north and south together with the Yellow River constrain homogeneous lateral urban expansion, while service connections among urban clusters depend more heavily on east–west transport corridors. Public service optimization in valley cities therefore cannot focus solely on straight-line distance between facilities and residents; it must also account for transport accessibility among spatially separated urban clusters.

Rail transit, bus rapid transit, and major urban transport corridors can provide crucial support for the cross-cluster sharing of public services. Coordinating education, healthcare, cultural and sports services, and daily-life services with key transport nodes can improve the shared use of higher-order facilities among urban clusters. Facilities whose service areas span multiple clusters should be more closely integrated with public transport networks so that the long spatial distances typical of linear

cities can be partly offset through transport organization. This can gradually produce a valley-city public service network characterized by "transport-corridor linkage–comprehensive-node support–community-facility coverage."

6. CONCLUSIONS AND DISCUSSION

6.1. Main Conclusions

Spatial analysis of the six categories of public service facility POIs in Lanzhou shows that the contiguous built-up areas spanning Chengguan, Qilihe, and Anning districts constitute the most stable high-value core of public services at the municipal scale. Peripheral counties form secondary concentrations mainly around county seats and local urban nodes, producing a clear decline in facility supply from the traditional central city toward peripheral areas. This shared gradient, however, does not eliminate functional differences among facility types. Healthcare, commercial, and cultural–sports facilities depend more strongly on the central urban area; public transport and basic education have broader node–network coverage; and elderly care facilities are few in number and lack continuous spatial coverage in peripheral areas.

Standard deviational ellipse and correlation analyses further show that all six facility types extend broadly along a northwest–southeast axis and have closely located spatial centers near the central urban area. This common orientation is strongly consistent with Lanzhou's urban structure, which is constrained by valley topography and major transport corridors. At the same time, facility pairs such as commercial–healthcare and healthcare–transport exhibit high spatial correlations, whereas the association between elderly care and commercial services is relatively weak. This indicates that the public service system combines multifunctional co-location with a relatively independent locational logic for facilities serving specific needs.

The integrated pattern generated through CRITIC-weighted overlay continues to exhibit a spatial hierarchy characterized by continuous high values in the central urban area and nodal distributions in peripheral areas. This suggests that public service optimization in Lanzhou should not rely on a uniform model of facility expansion. The central urban area should improve the efficiency of existing facilities and strengthen functional integration; peripheral counties should ensure basic public service coverage and reinforce county-seat and key-town nodes; new towns and development zones should synchronize facility provision with spatial development; and linear valley areas should enhance cross-cluster sharing through coordinated transport corridors and comprehensive service nodes.

6.2. Discussion

The core–periphery differences observed in Lanzhou's public service facilities should not be interpreted simply as "facility surplus" in the central city and "facility shortage" in peripheral areas. Population and service demand are themselves more concentrated in the central urban area, whereas peripheral counties have smaller populations and more dispersed settlements. Comparing only facility numbers and densities without accounting for the scale of demand may therefore misclassify normal hierarchical differences among spatial types as imbalances in provision. The present analysis is more suitable for revealing the spatial structure of facility supply. Assessing public service equity will require a unified framework that incorporates population size, age structure, facility hierarchy, and actual service capacity.

The significance of Lanzhou as a valley city should also extend beyond its role as background context. The long-term development of built-up areas along the Yellow River and major transport corridors provides a shared spatial basis for facility centrality, axial expansion, and nodal organization. More specifically, Lanzhou's historical evolution as a valley-based industrial city concentrated industrial land, employment, residential expansion, and major infrastructure along the Yellow River corridor

and east–west transport axes; this path-dependent development reinforced the central-city and service-node hierarchy observed today[8]. The valley morphology therefore operates not merely as a physical constraint, but as a mechanism that channels successive rounds of urban development and public-service investment into a limited set of linear corridors and nodes. In such cities, balanced public service provision does not necessarily mean a uniform spatial distribution of facilities. Rather, it may be achieved through accessibility balance, whereby service nodes at different hierarchical levels are connected by efficient transport networks. This provides the principal basis for extending the analysis from spatial pattern identification to differentiated planning responses.

6.3. Limitations and Future Research

POI data can identify facility locations and categories with relatively high accuracy, but they cannot directly capture hospital grades, school enrollment capacity, elderly care beds, or the actual service capacity of individual facilities. Consequently, the high-value areas identified in this study represent spatial concentrations of facilities rather than service capacity. In addition, the present analysis does not incorporate total population, age structure, or the needs of specific population groups. Whether facility supply is genuinely matched to residents' demand therefore cannot be determined from spatial density alone.

The use of data from a single time point also limits interpretation of the evolution of facility patterns. Future research could integrate gridded population data, older-adult and school-age populations, and facility-capacity indicators such as hospital beds and school enrollment capacity within a unified analytical framework. Combined with road-network accessibility and the two-step floating catchment area method, this would extend the research from "facility spatial distribution" toward an integrated evaluation of "facility supply–population demand–service accessibility." Multi-temporal POI data could also be used to identify structural adjustments in public service facilities accompanying Lanzhou's urban expansion.

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