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Accessibility and Spatial Differentiation of Elderly Care Service Facilities in Dalian

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Abstract: Population aging is changing the way elderly care services are planned. This paper takes the districts and county-level areas of Dalian as the study units. It distinguishes two common service scenarios: nearby daily life support and medium-distance institutional care with integrated medical–elderly care services. The study combines transport accessibility, the spatial dispersion of the older population, and service supply intensity. Based on these indicators, it builds a supply intensity–accessibility risk framework to identify service deficits and governance priorities. The results show a clear spatial differentiation in elderly care service accessibility in Dalian. The main urban area has a lower accessibility risk, while outer districts and county-level areas face a higher risk. Shahekou District, Zhongshan District, and Xigang District show relatively strong supply and low risk in both service scenarios. Their elderly care resources are more likely to be converted into an effective supply. Pulandian District, Wafangdian City, and Zhuanghe City face both insufficient supply and limited accessibility. These areas should be the key targets for systematic improvement. Different areas also show different dominant constraints. Jinzhou District and Lüshunkou District are mainly constrained by gaps in institutional care and integrated medical–elderly care services. Changhai County is affected by its island spatial structure, so it needs stronger daily life support and transfer services. Ganjingzi District has a more specific shortage in nearby daily life support services. Elderly care governance, therefore, needs to match service type, spatial accessibility, and supply–demand mismatch. This approach can support more precise area-based allocation of elderly care resources.

Keywords: Elderly care service facilities; Accessibility; Spatial differentiation; Dalian

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1. Introduction

Population aging is increasingly reshaping the way elderly care is understood and managed. Elderly care is no longer only a welfare issue. It has become an important issue of spatial governance and public service allocation [1–3]. In practice, the quality of life of older adults depends on more than the number of facilities available in a city. A more important question is whether older adults can actually reach these services within a reasonable travel time and use them when they need them [4–5].

This concern has become increasingly visible in many aging societies. As healthy aging moves to the center of global policy agendas, governments are paying more attention to how elderly care services are organized in space rather than simply how many facilities are provided [6–7]. As a result, elderly care systems are gradually shifting away from a development model based mainly on expanding beds and institutions. Greater emphasis is now placed on the coordination of long-term care, community support, medical–elderly care integration, and service accessibility. For countries experiencing rapid population aging, insufficient service supply remains an important challenge [8]. Yet many recent studies suggest that the real problem is often more complicated than a simple shortage of resources. A growing body of evidence points to the spatial mismatch between supply and demand as a critical issue [9].

In some areas, facilities are already available, but older adults still struggle to access them. Poor transport conditions, dispersed residential patterns, and large service catchment areas can prevent existing resources from becoming effective service opportunities. In other areas, travel conditions are relatively favorable, but service systems still suffer from structural shortages. These shortages may involve inadequate community support, insufficient medical–elderly care services, or an imbalance in the composition of available facilities. This situation raises an important question for aging cities. Should policymakers focus on building more facilities, or should they focus on improving the effectiveness of existing services? The answer often depends on local spatial conditions. Understanding where the main constraint lies has therefore become a key step in developing more precise and efficient elderly care policies.

Previous studies have examined the allocation of elderly care services from the perspectives of spatial equity, facility layout, service radius, and transport accessibility [10–11]. These studies have promoted the evaluation of elderly care facilities from total quantity accounting to spatial measurement. They have shown that older adults' access to services is affected by facility density, transport networks, population distribution, and urban–rural differences [12]. However, three gaps remain in the existing literature. Many studies treat elderly care services as a single service type, and pay limited attention to the different travel logics between daily life support and institutional care with medical–elderly care services [13]. Accessibility evaluation often emphasizes travel time or facility coverage, but gives insufficient attention to the decline in effective coverage caused by the spatial dispersion of the older population [14]. Supply evaluation and risk identification are also not well connected in an operational way [15]. As a result, many studies cannot clearly answer which areas should increase supply, which areas should improve accessibility first, and which areas need both types of policies at the same time.

China's urban elderly care service system is now shifting from scale expansion to precise allocation [16]. As the older population continues to grow, differences in demand intensity, transport support, and spatial form across urban districts and county-level areas are becoming larger [17]. A single balanced allocation logic can no longer meet practical governance needs [18]. Dalian is a typical coastal aging city. It has high-density main urban areas, outer districts, county-level areas, and island areas. Its elderly care service supply is affected by the combined effects of population concentration, spatial dispersion, accessibility differences, and uneven distribution of medical–elderly care resources. Therefore, using Dalian as a case to identify the spatial deficits of effective elderly care supply at the district and county level has clear practical significance and methodological value.

Against this background, this study develops a supply intensity–accessibility risk framework to better understand how elderly care services function across space. The framework starts from a simple observation. A district may have a considerable number of elderly care facilities, yet older residents may still struggle to access them. By the same token, a district with relatively good accessibility may continue to face service shortages if the supply structure does not match local needs. To capture these differences, this study distinguishes between two service scenarios. One scenario focuses on nearby daily life support. The other focuses on medium-distance institutional care and medical–elderly care services. These two scenarios reflect different patterns of service use. Daily life support is closely linked to routine activities and aging in place, while institutional and medical–elderly care services often require longer travel distances and stronger transport support. The framework combines three dimensions: transport accessibility, spatial dispersion of the older population, and scenario-specific supply intensity. This approach allows the analysis to move beyond a simple inventory of facilities. More importantly, it helps identify whether existing resources can actually be transformed into effective service opportunities for older adults in different districts and county-level areas of Dalian. Several questions naturally emerge from this perspective. Do elderly care accessibility risks follow a stable spatial pattern across the city? Do the same areas experience supply shortages under different service scenarios, or do the problems change with service type? When policymakers intervene, should they focus on increasing supply, improving accessibility, optimizing existing resources, or combining multiple strategies? These questions are not merely theoretical.

In many aging cities, districts with similar numbers of facilities often show very different service outcomes. Some areas struggle because resources are insufficient. Other areas struggle because resources are difficult to reach. Still others face mismatches between service provision and local demand. Understanding these differences is essential for effective policy design. This study, therefore, shifts the focus of elderly care evaluation away from facility counts alone. The analysis pays greater attention to effective supply, actual service accessibility, and spatial governance types. The resulting framework provides a clear and interpretable basis for identifying local service constraints. It also offers a transferable approach for the more precise allocation of elderly care resources in aging cities.

2. Materials and methods

2.1. Quantifying accessibility and effective supply of elderly care services

2.1.1. Defining service scenarios

This study uses two service scenarios. They correspond to two typical ways of obtaining elderly care services and two acceptable levels of travel time cost. The first scenario is being nearby daily life support. It is based on walking accessibility. The target groups include older adults aged 60 to 64 and those aged 65 and above. The service content mainly covers daily and continuous needs. This scenario is characterized by high service frequency, a short service radius, and stronger sensitivity to spatial dispersion. The second scenario is medium-distance institutional care with integrated medical–elderly care services. It is based on accessibility by public transport or private car. The target group is mainly older adults aged 65 and above. The service content mainly covers institutional care and medical–elderly care support. This scenario has a larger service radius, higher time cost, and stronger sensitivity to transport accessibility. At the district and county level, the accessibility assessment does not directly output travel time in minutes. Instead, it measures whether accessibility constraints under each scenario are higher or lower than the citywide average. This result is then used to adjust the effectiveness of supply intensity and to form a risk axis for classification.

2.1.2. Transport accessibility condition index T$_i$

Transport accessibility at the district and county level determines whether older adults can realistically reach elderly care service sites. It is an important prerequisite for effective coverage. Transport facilities are not elderly care supply themselves, but they determine travel support capacity. This is especially important in the medium-distance institutional care scenario with integrated medical–elderly care services, where transport accessibility often becomes a decisive constraint on the usability of supply. This study uses transport facility density as a proxy variable for district and county transport accessibility. This indicator is comparable across districts and county-level areas. It can also reflect the overall concentration of roads, hubs, stations, and transport service resources. Considering the extremely high values of transport density in the main urban area, direct standardization may enlarge differences and distort the relative ranking among districts and county-level areas. Therefore, this study first applies an transformation to transport facility density to reduce the influence of extreme values, and then standardize the transformed value to obtain the transport accessibility condition index:

$$T_i = \frac{ln(1+\text{transport facility density}_i) - ln(1+\text{transport }\overline{\text{f}}\text{acility density})}{\sigma_{ln(1+\text{transport facility density})}} \tag{1}$$

In the final standardized results, $Ti > 0$ indicates that the transport accessibility condition of a district or county-level area is better than the citywide average. In contrast, $Ti < 0$ indicates that transport accessibility is weaker than the citywide average. The interpretation is straightforward. Higher accessibility means that older adults can reach more service opportunities at the same travel cost. It also means that existing service resources are more likely to be transformed into effective coverage. Lower accessibility suggests the opposite situation. In these areas, service facilities may already exist, yet older adults may still face difficulties reaching them. As a result, the effectiveness of supply can remain limited even when the quantity of supply is not particularly low.

2.1.3. Spatial dispersion index Spre$_i$

The more dispersed the residential and facility distribution within a district or county-level area, the more difficult it is for nearby services to form stable coverage. Under the same service-site density, dispersed areas are less likely to generate the same level of effective service opportunities. At the district and county level, it is difficult to directly capture the detailed spatial structure within towns, townships, and subdistricts. Therefore, this study uses the reciprocal of older population density to measure residential dispersion. A lower density indicates a more dispersed residential pattern, which makes it harder for nearby daily life support services to achieve high coverage. The dispersion levels of older adults aged 60 to 64 and those aged 65 and above are calculated and standardized separately:

$$Spre_i^{60} = Std\left(\frac{1}{D_{60,i}}\right), Spre_i^{65} = Std\left(\frac{1}{D_{65,i}}\right) \tag{2}$$

Considering that daily life support is more rigidly needed by the older age group, while also covering the early-stage needs of adults aged 60 to 64, this study combines the two dispersion measures into an overall district-level spatial dispersion index:

$$Spre_i = 0.4 \times Spre_i^{60} + 0.6 \times Spre_i^{65} \tag{3}$$

A larger $Spre_i$ indicates a more dispersed older population and greater difficulty in forming effective coverage for nearby services. This indicator can be interpreted as follows: in districts and county-level areas with high spatial dispersion, even when per capita supply is not low, service sites may still exist without producing strong coverage. Governance tools should therefore focus more on service network densification and transport connection, rather than simply increasing the stock of facilities.

2.1.4. Accessibility risk indices for the two service scenarios: $Risk_i^{walk}$ and $Risk_i^{drive}$

To integrate transport accessibility and spatial dispersion into a unified risk axis, this study constructs two scenario-specific risk indices. Both indices use 0 as the citywide average line. A larger value indicates stronger accessibility constraints and greater difficulty in converting supply into effective service coverage. The weights of the two risk indices reflect the differences between the two scenarios. Nearby daily life support is more constrained by spatial dispersion, while medium-distance institutional care with integrated medical–elderly care services is more constrained by transport accessibility. The indices are defined as follows:

$$Risk_i^{walk} = 0.7 \times Spre_i - 0.3 \times T_i \tag{4}$$

$$Risk_i^{drive} = 0.3 \times Spre_i - 0.7 \times T_i \tag{5}$$

When $Risk > 0$, the ,accessibility constraint of the district or county-level area under the corresponding scenario is higher than the citywide average. This indicates that effective coverage is more difficult to achieve. When $Risk \leq 0$, the accessibility constraint is not higher than the citywide average, and supply is more likely to be converted into effective service opportunities.

2.1.5. Quadrant identification based on supply intensity and accessibility risk

This study conducts quadrant identification for the two service scenarios separately. The horizontal axis represents scenario-specific supply intensity. The vertical axis represents scenario-specific accessibility risk. This study uses 1 as the threshold for supply intensity. Values above 1 indicate a strong supply. Values below 1 indicate weak supply. This study uses 0 as the threshold for accessibility risk. Values above 0 indicate high risk. Values below 0 indicate low risk.

Q1 represents a strong supply and low risk. It includes districts and county-level areas with relatively favorable conditions. These areas should shift their governance focus from facility expansion to efficiency improvement and structural optimization.

Q2 represents a strong supply but high risk. It includes districts and county-level areas dominated by accessibility constraints. These areas do not mainly lack service sites. Their main problem is weak effective coverage. This problem may result from poor transport accessibility or spatial dispersion. These areas should prioritize connection services, transport optimization, mobile services, and outreach-based supply. They should not rely only on expanding service sites.

Q3 represents weak supply but low risk. It includes districts and county-level areas dominated by supply shortages. In these areas, transport accessibility and population concentration are not the main barriers. Filling gaps in service sites or service capacity is therefore more likely to produce direct improvement. These areas also need to check whether the supply structure has missing components.

Q4 represents weak supply and high risk. It includes districts and county-level areas with dual constraints. These areas face both insufficient supply capacity and limited effective coverage. Governance should combine supply improvement with an accessibility organization. The order of priority should be determined by the service scenario.

At the district and county level, this study defines Q2 as accessibility-dominated. It defines Q3 as supply-shortage-dominated. It defines Q4 as dual-constraint. It defines Q1 as efficiency optimization, as shown in **Figure 1**. Supply intensity at the district and county level must meet two requirements. It should cover three types of supply: institutional elderly care supply, medical–elderly care related supply, and daily life support supply. It should also match the two service scenarios. This design avoids using one supply measure to explain different service scenarios.

This study has calculated per capita supply and the location quotient, LQ, for the three types of supply. The calculation covers older adults aged 60 to 64 and those aged 65 and above. Based on these results, this study constructs two scenario-specific supply intensity indices without changing the original definition of the three types of supply. The first index is the supply intensity axis for the nearby daily life support scenario. It takes daily life support as the main component and medical–elderly care support as the supplementary component. It also considers the joint demand for nearby services among older adults aged 60 to 64 and those aged 65 and above. First, a mixed location quotient is calculated across the two age groups:

$$LQ_{mix,i}^{life} = 0.6 \cdot LQ_{65,i}^{life} + 0.4 \cdot LQ_{60,i}^{life} \tag{6}$$

$$LQ_{mix,i}^{med} = 0.6 \cdot LQ_{65,i}^{med} + 0.4 \cdot LQ_{60,i}^{med} \tag{7}$$

It is then combined into the supply intensity for the nearby daily life support scenario:

$$Supply_i^{near} = 0.7 \cdot LQ_{mix,i}^{life} + 0.3 \cdot LQ_{mix,i}^{med} \tag{8}$$

The second index is the supply intensity axis for the medium-distance institutional care and medical–elderly care scenario. It is mainly driven by older adults aged 65 and above. Core elderly care facilities and medical–elderly care support jointly determine the usability of medium-distance services:

$$Supply_i^{mid} = 0.6 \cdot LQ_{65,i}^{core} + 0.4 \cdot LQ_{65,i}^{med} \tag{9}$$

$Supply \geq 1$ indicates that supply under the corresponding scenario is stronger than the citywide average, while $Supply < 1$ indicates that supply is weaker than the citywide average.

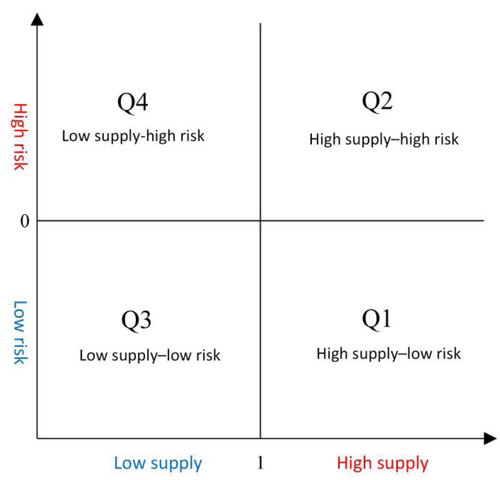

Figure 1. Quadrant diagram of supply intensity and accessibility risk

3. Results

3.1. Accessibility of elderly care supply constrained by transport accessibility and population dispersion

The accessibility challenges facing elderly care services in Dalian are far from uniform. Different districts and county-level areas experience different combinations of transport conditions and population distribution patterns. In general, the main urban area benefits from convenient transport networks and a relatively concentrated older population. By contrast, many outer districts and county-level areas face weaker transport support and more dispersed residential patterns, which makes effective service coverage much harder to achieve.

To facilitate comparison across areas, this study standardizes both transport accessibility and population dispersion. A transport accessibility value above zero indicates better travel conditions than the citywide average, whereas a value below zero indicates weaker conditions. Population dispersion follows the opposite logic. Higher values represent a more dispersed older population and greater difficulty in achieving service coverage. Lower values indicate a more concentrated population, allowing a limited number of service facilities to serve a larger share of residents. The results reveal a clear spatial pattern. Xigang District, Shahekou District, and Zhongshan District show the most favorable conditions in the city. Their transport accessibility values reach 1.515, 1.418, and 1.366, while their population dispersion values remain at −1.076, −1.081, and −1.049. These figures suggest that older residents are concentrated in areas with strong transport support. As a result, service resources in these districts can be converted into effective coverage more easily.

A very different pattern appears in Pulandian District, Wafangdian City, and Zhuanghe City. All three areas combine weak transport accessibility with a highly dispersed older population. Their transport accessibility values are −0.970, −0.965, and −0.965, while their population dispersion values reach 0.745, 1.206, and 1.802. Together, these two factors create the strongest accessibility constraints in Dalian. The situation in these areas highlights a common challenge in large peripheral districts and county-level areas. Service facilities may exist, but older residents are often scattered across a wide geographic space. Under these conditions, the effectiveness of service provision depends not only on how many facilities are available but also on whether residents can realistically reach them. The problem becomes especially pronounced when transport support is weak. Zhuanghe City stands out within this group. Its population dispersion value reaches 1.802, the highest level among all districts and county-level areas. This result suggests that older residents are distributed across a much broader area than elsewhere in the city. In a setting like this, adding a small number of fixed facilities is unlikely to generate substantial improvements in service coverage. A more effective approach would combine service expansion with better service organization and improved travel support. Mobile services, outreach programs, and transport coordination may be just as important as building new facilities.

Not every district fits neatly into either the high-constraint or low-constraint category. Ganjingzi District provides a useful example. Its transport accessibility value is 0.229, slightly above the citywide average, while its population dispersion value is −0.907. These figures indicate that older residents are relatively concentrated and that travel conditions are generally favorable. From the perspective of accessibility, Ganjingzi already has many of the conditions needed to support effective service coverage. This finding raises a different question. If accessibility is not the main problem, what explains the remaining service gap? The evidence suggests that the challenge in Ganjingzi lies more on the supply side. Existing transport conditions allow services to reach residents relatively efficiently. The key issue is whether the current service structure and service capacity are sufficient to match the scale and composition of local demand. In other words, Ganjingzi appears to need better-targeted services rather than better accessibility.

Ganjingzi District has a transport accessibility condition value of 0.229, slightly higher than the citywide average, and a population dispersion value of −0.907, clearly lower than the average. This indicates that its residential concentration is favorable for nearby service coverage. Its accessibility constraints are relatively controllable, and the key issue is more likely to shift toward whether the supply structure and service carrying capacity match the scale of demand. Lüshunkou District has a transport accessibility condition value of −0.340, lower than the citywide average, but its population dispersion value is −0.422, which is still below the average. This suggests that its main deficit is more related to transport accessibility than to residential dispersion. Jinzhou District has a transport accessibility condition value of −0.534, lower than the average, and a population dispersion value of 0.381, higher than the average. It is a district with dual constraints of moderate intensity. This suggests that relying only on the natural coverage of existing facilities is unlikely to fully release service effectiveness, and that node supplementation and accessibility improvement should be considered at the same time. Changhai County has a transport accessibility condition value of −0.755 and a population dispersion value of 0.403. It shows weak transport accessibility and relatively high spatial dispersion. At the same time, it also faces structural travel restrictions caused by its island spatial setting. For this type of area, district- and county-level average values often underestimate the dispersion of actual travel costs.

From a district- and county-level governance perspective, Pulandian District, Wafangdian City, and Zhuanghe City stand out as the areas facing the most severe combined constraints. These areas experience both weak transport accessibility and high population dispersion. The two factors reinforce each other and make effective service coverage particularly difficult to achieve. As a result, these districts and county-level areas should be treated as priority targets for intervention. The situation in Lüshunkou District is somewhat different. The main challenge there is not population dispersion but transport accessibility. Older residents are relatively concentrated, yet travel conditions remain weaker than the citywide average. This pattern suggests that improving transport connections and strengthening cross-area service coordination would likely generate greater benefits than simply increasing the number of facilities.

A different picture emerges in Ganjingzi District and the three core urban districts. These areas already enjoy relatively favorable accessibility conditions. Older residents are more concentrated, and travel support is generally stronger. In such places, accessibility is no longer the main bottleneck. The more pressing task is to optimize the existing service structure, improve service quality, and increase operational efficiency. In other words, these areas need better allocation of resources rather than substantial expansion of infrastructure. Jinzhou District and Changhai County also face dual constraints, but the underlying causes are not the same. Jinzhou District combines moderate accessibility problems with a certain degree of population dispersion. This pattern suggests that neither supply expansion nor accessibility improvement alone is likely to solve the problem. A combined strategy that adds service nodes while improving accessibility is more appropriate. Changhai County presents a special case. Its island geography creates structural barriers that cannot be fully captured by conventional accessibility indicators. Even when facilities are available, residents may still face substantial travel difficulties because of ferry dependence and geographic isolation. Under these conditions, organized service delivery, transfer support, and coordinated transport arrangements become particularly important. The value of this classification lies in its ability to translate accessibility from an abstract concept into a practical governance tool. Accessibility is no longer treated as a general background condition. Instead, it becomes a measurable constraint that can be classified, prioritized, and linked to specific policy responses. This framework also provides a clear district- and county-level basis for identifying the sources of supply–demand mismatch and for adjusting effective supply in a more targeted manner, as shown in **Table 1**.

Table 1. Transport accessibility conditions and population dispersion across districts and county-level areas

Districts and county-level areas	Transport accessibility conditions	Population dispersion
Jinzhou	-0.534	0.381
Lüshunkou	-0.340	-0.422
Pulandian	-0.970	0.745
Shahekou	1.418	-1.081
Wafangdian	-0.965	1.206
Changhai	-0.755	0.403
Zhuanghe	-0.965	1.802
Zhongshan	1.366	-1.049
Ganjingzi	0.229	-0.907
XiGang	1.515	-1.076

3.2. Identification of accessibility risk gradients and key constrained areas under the two service scenarios

Based on the accessibility risk results under the two service scenarios, accessibility differences among districts and county-level areas in Dalian show a clear polarization. The main urban area and its surrounding districts are generally located in the low-risk range. The outer large districts, county-level areas, and island areas are generally located in the high-risk range. The risk rankings under the two scenarios are highly consistent. Accessibility constraints show a stable spatial structure and reflect rigid differences at the district and county levels.

Accessibility risk shows a clear gradient from lower risk in the main urban area to higher risk in outer areas. The directions are consistent under both the nearby daily life support scenario and the institutional care with integrated medical–elderly care services scenario. Shahekou District, Zhongshan District, and Xigang District have significantly negative values for both risks. Their nearby daily life support risks are −1.182, −1.144, and −1.208, respectively. Their institutional care with integrated medical–elderly care services risks are −1.317, −1.271, and −1.383, respectively. This indicates that, under the two typical travel scenarios, barriers to service access in these districts are lower than the citywide average. They have a strong basis for effective coverage. In contrast, Zhuanghe City, Wafangdian City, and Pulandian District have positive values for both risks, with relatively large magnitudes. Their nearby daily life support risks are 1.551, 1.134, and 0.812, respectively. Their institutional care with integrated medical–elderly care services risks are 1.216, 1.037, and 0.903, respectively. This means that these areas face strong constraints under both the walking scenario and the medium-distance travel scenario. They are districts and county-level areas with prominent accessibility deficits. Changhai County also has positive values for both risks, at 0.508 and 0.649, respectively. This indicates that although it is small in scale, the constraints caused by transport accessibility conditions and spatial dispersion should not be ignored, as shown in **Table 2**.

The risk intensity of the two scenarios is generally consistent. For most districts and county-level areas, the risk of institutional care with integrated medical–elderly care services changes in the same direction as the risk of nearby daily life support. This indicates that transport accessibility and population dispersion have a synchronous effect on the two types of service opportunities. However, differences in individual areas still provide operational policy implications. For example, the nearby daily life support risk of Lüshunkou District is −0.194, which is lower than the citywide average, while its institutional care with integrated medical–elderly care services risk is 0.111, which is higher than the citywide average. This indicates that Lüshunkou District has relatively favorable access to nearby services, but faces more obvious time-cost constraints in accessing medium-distance medical care, rehabilitation, and institutional services. Jinzhou District has positive values for both risks, and its institutional care with integrated medical–elderly care services risk is higher than its nearby daily life support risk, 0.488 compared with 0.427. This suggests that Jinzhou District is more likely to face stronger constraints in medium-distance service access. Ganjingzi District has negative values for both risks, with a nearby daily life support risk of −0.704 and an institutional care with integrated medical–elderly care services risk of −0.432. This indicates that its overall transport accessibility conditions are relatively good and its dispersion constraints are relatively weak. However, the absolute value of its institutional care with integrated medical–elderly care services risk is smaller, suggesting that its advantage in medium-distance service access is not as clear as its advantage in nearby daily life support. It is therefore necessary to further assess whether this area has low risk but insufficient supply by combining these results with the supply intensity indicators.

Table 2. Accessibility risks across districts and county-level areas under the two service scenarios

Districts and county-level areas	Nearby daily life support risk	Institutional care and medical–elderly care risk
Jinzhou	0.427	0.488
Lüshunkou	-0.194	0.111
Pulandian	0.812	0.903
Shahekou	-1.182	-1.317
Wafangdian	1.134	1.037
Changhai	0.508	0.649
Zhuanghe	1.551	1.216
Zhongshan	-1.144	-1.271
Ganjingzi	-0.704	-0.432
XiGang	-1.208	-1.383

3.3. Identification of deficit types and governance priorities across districts and county-level areas under the two scenario quadrants

3.3.1. Full-chain service gap type: Both service scenarios fall into the Q4 quadrant

This type of area has the highest priority. It mainly includes Pulandian District, Wafangdian City, and Zhuanghe City. The basis for this classification is that the supply intensity of nearby daily life support is lower than the citywide average, while the risk of nearby daily life support is higher than the citywide average. At the same time, the supply intensity of institutional care with integrated medical–elderly care services is lower than the citywide average, while the risk of institutional care with integrated medical–elderly care services is higher than the citywide average. The key feature of these areas is not the weakness of a single type of facility. Instead, both service chains are weak, and this is combined with relatively insufficient transport accessibility and relatively dispersed population distribution.

As a result, the existing supply stock is difficult to convert into effective accessibility. In terms of governance, these areas need to improve the basic network of nearby daily life support. Priority should be given to making meal assistance, convenience services, day care, and community support services continuously available. They also need to strengthen the key capacities of institutional care with integrated medical–elderly care services, especially nursing beds, rehabilitation care, primary medical services, and referral coordination. At the same time, transport connections and mobile services should be improved to reduce the time cost in high-risk areas and ensure that new supplies can form actual coverage. The priority order for resource allocation is Zhuanghe City, Wafangdian City, and Pulandian District. Zhuanghe City has the highest risk under both scenarios and is the most typical area with overlapping accessibility constraints. Wafangdian City has the second-highest risk and a relatively large service population, so it has greater potential for effective investment. Although Pulandian District also falls into Q4 for both supply intensity and risk under the two scenarios, its risk level is lower than that of Zhuanghe City and Wafangdian City. It is therefore more suitable for parallel structural gap-filling and staged target attainment, as shown in **Table 3**.

3.3.2. Institutional and medical–elderly care service gap-dominated type: Q4 in the institutional care scenario and non-Q4 in the nearby daily life support scenario

This type of area has the second-highest priority. It mainly includes Jinzhou District and Lüshunkou District. Their common feature is that the institutional care and medical–elderly care side falls into the Q4 quadrant. This indicates a clear gap in the medium-distance service system at the district and county level. However, the degree of constraint on nearby daily life support differs between the two areas, so their governance measures should be differentiated.

Jinzhou District falls into the Q2 quadrant for nearby daily life support. It is accessibility-dominated, and its supply is stronger than the citywide average. It falls into the Q4 quadrant for institutional care and medical–elderly care, indicating dual constraints. This shows that daily life support supply is not weak, but its effective coverage may still be insufficient because of accessibility constraints. More importantly, the institutional care and medical–elderly care side has a weak supply and a high risk. Insufficient usability of medium-distance services is the main problem. Priority should be given to improving the supply capacity of core facilities and medical–elderly care support. The focus should be on filling gaps in nursing beds, rehabilitation care, primary medical services, and referral coordination. Transport connection, transfer mechanisms, and cross-district coordination should also be used to reduce time costs. For daily life support, large-scale repeated additions of service sites are not appropriate. The focus should be on filling coverage gaps, improving efficiency, and strengthening service connectivity.

Lüshunkou District falls into the Q1 quadrant for nearby daily life support, with strong supply and low risk. However, it falls into the Q4 quadrant for institutional care and medical–elderly care, and its supply intensity is close to the citywide average threshold. This indicates that its daily life support can generally be maintained, while the institutional care and medical–elderly care side represents a borderline service gap. It is suitable for filling weak links in medical–elderly care resources and improving cross-district referral coordination. Transport and connection improvements can also be used to reduce the time cost of medium-distance travel. With relatively small inputs, these measures can help shift the quadrant from Q4 to Q3 or Q2.

Priority should be given to pilot projects that can be tested and verified quickly, as shown in **Table 3**.

Jinzhou District falls into the Q2 quadrant for nearby daily life support. It is accessibility-dominated, and its supply is stronger than the citywide average. It falls into the Q4 quadrant for institutional care and medical–elderly care, indicating dual constraints. This shows that daily life support supply is not weak, but its effective coverage may still be insufficient because of accessibility constraints. More importantly, the institutional care and medical–elderly care side has a weak supply and a high risk. Insufficient usability of medium-distance services is the main problem. Priority should be given to improving the supply capacity of core facilities and medical–elderly care support. The focus should be on filling gaps in nursing beds, rehabilitation care, primary medical services, and referral coordination. Transport connection, transfer mechanisms, and cross-district coordination should also be used to reduce time costs. For daily life support, large-scale repeated additions of service sites are not appropriate. The focus should be on filling coverage gaps, improving efficiency, and strengthening service connectivity. Lüshunkou District falls into the Q1 quadrant for nearby daily life support, with strong supply and low risk. However, it falls into the Q4 quadrant for institutional care and medical–elderly care, and its supply intensity is close to the citywide average threshold. This indicates that its daily life support can generally be maintained, while the institutional care and medical–elderly care side represents a borderline service gap. It is suitable for filling weak links in medical–elderly care resources and improving cross-district referral coordination. Transport and connection improvements can also be used to reduce the time cost of medium-distance travel. With relatively small inputs, these measures can help shift the quadrant from Q4 to Q3 or Q2. Priority should be given to pilot projects that can be tested and verified quickly, as shown in **Table 3**.

3.3.3. Nearby daily life support service gap-dominated type: Q4 in the nearby daily life support scenario and Q2 in the institutional care scenario

This type mainly refers to Changhai County. The classification is based on the fact that its supply intensity for nearby daily life support is significantly lower than the citywide average, while its nearby daily life support risk is higher than the citywide average. At the same time, its supply intensity for institutional and medical–elderly care services is higher than the citywide average, but its institutional and medical–elderly care risk remains higher than the citywide average. This type of district or county-level area does not have weak institutional and medical–elderly care resources in quantitative terms. However, under the influence of spatial conditions and transport accessibility constraints, these resources are difficult to convert steadily into usable service opportunities. More importantly, the nearby daily life support system is relatively weak. This is directly related to the basic guarantee of continuous home-based care and essential daily care. Changhai County should not be placed at a lower priority simply because of its population size. It is necessary to appropriately improve the continuous supply of nearby daily life support and build a basic service chain that reaches villages and communities. In addition, the capacity for emergency transfer and routine referral should be strengthened to ensure that institutional and medical–elderly care resources are accessible and usable at critical times, as shown in **Table 3**.

3.3.4. Nearby daily life support service gap type in Q3 and institutional and medical–elderly care advantage type in Q1

This type is best represented by Ganjingzi District. The results suggest that transport accessibility is not the primary challenge in this area. A more important issue lies in how services are distributed and whether the existing service structure matches local needs. For this reason, policy efforts should focus more on service provision and spatial layout than on transport improvement. The two service scenarios reveal a clear contrast. In the nearby daily life support scenario, Ganjingzi District falls into the Q3 quadrant. This position indicates a supply-shortage-dominated type. In the institutional and medical–elderly care scenario, however, the district falls into the Q1 quadrant, which represents strong supply and low risk. This difference is meaningful because it suggests that the district does not face a general shortage of elderly care resources. The problem is concentrated in the services that older adults use most frequently in their daily lives. The underlying indicators support this interpretation. The supply intensity of nearby daily life support remains below the citywide average, yet the associated risk is also below the citywide average. In practical terms, older residents in Ganjingzi do not face major accessibility barriers. The district benefits from relatively favorable transport conditions and a concentrated population distribution. These conditions make it easier for services to reach residents. As a result, accessibility is unlikely to be the main factor limiting service effectiveness.

What, then, explains the observed gap? The evidence points to weaknesses in the supply system itself. The shortage may appear as an insufficient number of service sites, uneven distribution among neighborhoods, or a mismatch between available services and local demand. Similar patterns are often found in large urban districts where overall resource levels seem adequate, yet some communities still lack convenient access to everyday support services. The policy implications are relatively clear. Ganjingzi District should strengthen the continuous provision of meal assistance, convenience services, community support programs, and other forms of nearby daily life support. These services play a critical role in supporting aging in place and maintaining daily well-being. Expanding and optimizing these services would help address local shortages that can easily be overlooked when only district-level averages are considered. Transport improvement may still contribute to service quality, but its marginal benefit is likely to be limited. The district already possesses relatively favorable accessibility conditions. Under these circumstances, improving what is supplied and where it is supplied is likely to generate greater benefits than further improving transport accessibility. Therefore, transport measures should be treated as a supporting tool rather than the primary policy response, as shown in **Table 3**.

3.3.5. Effective supply type: Both service scenarios fall into the Q1 quadrant

This type of district should shift toward structural optimization and efficiency improvement while maintaining service coverage. It mainly includes Shahekou District, Zhongshan District, and Xigang District. Both service chains in these districts show strong supply and low risk, so they can be regarded as effective supply areas at the district and county level. The classification is based on the fact that the supply intensity of both nearby daily life support and institutional and medical–elderly care services is higher than the citywide average, while the risks under both scenarios are lower than the citywide average. The governance focus for these districts should be to improve the efficiency and quality of existing services, strengthen the coordinated operation of nursing, rehabilitation, medical–elderly care linkage, and daily support, and promote targeted micro-renewal in old neighborhoods and marginal areas. This can help prevent local service gaps within districts that are generally effective in overall terms. These districts should also undertake service spillover and referral-receiving functions across districts, form support channels for surrounding areas with service gaps, and convert the advantages of the main urban area into resilience of the citywide service system, as shown in **Table 3**.

Table 3. Identification and classification of service gap types across districts and county-level areas under the two scenario quadrants

District	Nearby daily life support	Quadrant	Institutional care and medical–elderly care	Quadrant
Jinzhou	1.265	Q2 Accessibility-dominated	0.887	Q4 Dual constraints
Lüshunkou	1.083	Q1 Strong supply and low risk	0.942	Q4 Dual constraints
Pulandian	0.535	Q4 Dual constraints	0.770	Q4 Dual constraints
Shahekou	1.379	Q1 Strong supply and low risk	1.114	Q1 Strong supply and low risk
Wafangdian	0.715	Q4 Dual constraints	0.731	Q4 Dual constraints
Changhai	0.314	Q4 Dual constraints	1.614	Q2 Accessibility-dominated
Zhuanghe	0.627	Q4 Dual constraints	0.685	Q4 Dual constraints
Zhongshan	2.072	Q1 Strong supply and low risk	1.410	Q1 Strong supply and low risk
Ganjingzi	0.929	Q3 Supply-shortage-dominated	1.319	Q1 Strong supply and low risk
Xigang	1.840	Q1 Strong supply and low risk	1.649	Q1 Strong supply and low risk

4. Conclusion

(1) The accessibility differentiation of elderly care supply across districts and county-level areas in Dalian shows a clear polarization. The main urban area has strong transport accessibility, a concentrated older population, and low risk under both service scenarios. In contrast, the outer districts and county-level areas have weak transport accessibility, a dispersed older population, and a high risk under both scenarios. The main causes of mismatch can be clearly distinguished as supply-shortage-dominated or accessibility-dominated.

(2) Shahekou District, Zhongshan District, and Xigang District have transport accessibility conditions that are clearly above the citywide average, and their older population is more concentrated. They form the core area with the lowest accessibility constraints in the city. Pulandian District, Wafangdian City, and Zhuanghe City have weak transport accessibility and high population dispersion. They are the areas where transport constraints and coverage difficulty overlap most strongly. Jinzhou District has weak transport accessibility but moderate population dispersion. Changhai County has weak transport accessibility and special spatial isolation constraints caused by its island setting. These areas should be considered separately.

(3) Under both the nearby daily life support scenario and the institutional and medical–elderly care scenario, Zhuanghe City, Wafangdian City, and Pulandian District have risks that are clearly higher than the citywide average. This indicates that insufficient travel support and dispersed residence patterns jointly increase the difficulty of achieving effective coverage for both types of services. Shahekou District, Zhongshan District, and Xigang District have risks that are clearly lower than the citywide average under both scenarios. This indicates that their service opportunities are more likely to be converted into effective supply under reasonable travel time costs. Ganjingzi District has negative risk values under both scenarios, suggesting that its main problem does not lie in transport accessibility constraints.

(4) The full-chain service gap areas are Pulandian District, Wafangdian City, and Zhuanghe City. They face dual constraints under both service scenarios and should be treated as the highest-priority areas for systematic gap-filling at the district and county level. Jinzhou District and Lüshunkou District are mainly constrained by institutional and medical–elderly care service gaps. The focus should shift to

core facilities, medical–elderly care support capacity, and cross-district coordination, rather than adding daily life support sites. Changhai County has a daily life support gap and is also affected by spatial isolation. It should be promoted separately as a key area for strengthening basic elderly care security. Ganjingzi District is supply-shortage-dominated but does not have a high risk, so priority can be given to improving local layout and filling structural gaps. Shahekou District, Zhongshan District, and Xigang District are effective supply areas under both service scenarios. Their focus should shift toward stock optimization and efficiency improvement, while also helping to absorb elderly care pressure from outer areas.

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