


## Article

# Evaluation of the Quality of the Age-Friendly Environment in Liaoning Province

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**Abstract:** The age friendliness of an environment is significant for improving the quality of life of the elderly. This metric is an important measure used by the international community to address the challenges of population aging. In order to explore effective ways to improve the quality of an age-friendly environment, this study considers the theoretical framework of the World Health Organization and combines China's demographic and policy conditions to develop an urban-scale indicator system for the evaluation of the age-friendly environment (AFE) by including the dimensions of social and physical environments and municipal services. The entropy method and multiple linear regression were used to study the changes and influencing factors of the quality of AFE in 14 prefecture-level cities in Liaoning Province. The research results are as follows. First, temporally, the comprehensive quality of AFE in the cities in Liaoning Province was at a relatively low level, and the overall trend was decreasing. During the evaluation period, the level of age friendliness in various cities was generally low, with a relatively small number of cities scoring higher. Second, spatially, significant regional differences in the age friendliness of the environment existed, which showed spatial patterns of "high in the middle and low on both sides" and "strong in the south and weak in the north". Third, the dimensions were in the order of physical environment > municipal services > social environment. The social environment was weak for the construction of AFEs in Liaoning Province, and efforts are required to strengthen it in the future. Fourth, aging rate was negatively correlated with the level of AFE. The positively correlated factors were in the order of expenditure for urban and rural community affairs > per capita GDP > per capita disposable income of urban residents. This study provides insights for cities to improve the quality of AFEs, actively respond to population aging, and help promote WHO initiatives in developing countries.

**Keywords:** human settlements; age-friendly cities; age-friendly environment



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## 1. Introduction

Aging of the population is one of the most significant characteristics of global population development. China has the largest elderly population in the world, and according to the results of the seventh population census, the proportion of people aged 60 and above in China has increased by 5.44% compared with 2010. Especially starting from 2022, as a result of the gradual aging of China's baby boom population of the 1960s, the population-scale aging process has intensified [1]. The rapidly expanding elderly population not only means a significant change in the population structure, but it will also have a profound impact on social sustainable development and all aspects of social life. We cannot avoid or change this phenomenon and can only take effective measures to respond proactively to ensure a good quality of life for the elderly. With the continuous increase in population aging worldwide, the international community's awareness of and actions to address the challenges of population aging are continuously increasing. The effective alleviation of the pressure of aging and improving the quality of life of the elderly have become important global issues [2,3]. The construction of and research on the age-friendly environment (AFE)

is a positive response and is beneficial for the international community to address the challenges related to aging [4].

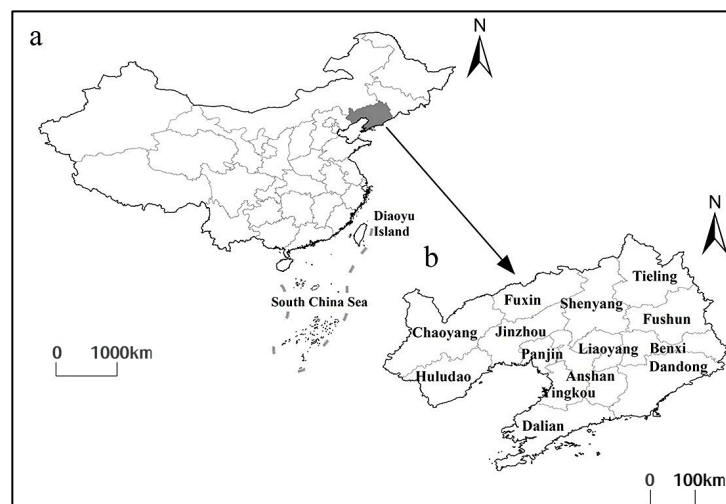
In 2005, the Global Age-Friendly Cities Framework promoted by the World Health Organization (WHO) sparked a wave of initiatives toward age friendliness. In 2007, based on a survey of 33 cities in 22 countries around the world, WHO released the Global Age-Friendly Cities Guide aimed at promoting the creation of accessible and inclusive urban environments. The WHO initiative quickly spread and gained worldwide recognition [5,6].

Under the influence and promotion of WHO, many countries and regions around the world have carried out the construction of AFEs, and research on related issues in disciplines such as public policy, sociology, medicine, and geography has gained considerable attention. Research has shown that the happiness of the elderly, in their later years, is closely related to their environment, which has a significant impact on their mobility, wellbeing, and quality of life [7–9]. Limited physical activity and loneliness are risk factors that lead to physical and cognitive decline in the elderly [10]. The building environment pertaining to health-related goods and services is related to improving health outcomes [11,12]. An environment that is suitable for the needs of the elderly can help them successfully achieve home-based elderly care [13]. At present, research on AFEs involves exploring their connotations and characteristics [14], evaluation indicators and tools [15–19], construction methods and approaches [20–23], and typical cases and construction experiences [24–27]. In China, influenced by WHO, scholars have begun to pay attention to the construction of AFEs. For example, in 2013, the newly revised “Law of the People’s Republic of China on the Protection of the Rights and Interests of the Elderly” included a separate chapter on “livable environments”, which greatly promoted the research enthusiasm of scholars. Since then, the number of papers on elderly-friendliness has greatly increased. Based on the research experience of foreign scholars, Chinese scholars have explored the connotation and theoretical basis of AFEs [28], construction strategies [29–31], impact of living environment on the elderly [32,33], and living needs and experiences of the elderly [34,35]. However, more work remains to be completed. Owing to the early onset of aging in Western countries and the implementation of practices and research related to AFEs, researchers have mostly focused on the study of cities and regions in Western countries; therefore, attention to developing countries and cases from non-Western backgrounds are lacking. Like other developing countries, China’s population demographics and socioeconomics are different from those of developed countries. Specifically, China’s population is aging before achieving financial independence, culminating in a scenario in which there are limited resources available to meet the needs of the elderly on a large scale [36]. Overall, the construction of AFEs is a major challenge in the context of developing countries. Therefore, strengthening research on Chinese cities will help promote the application of the WHO’s initiatives in developing countries. The aim of the study is to explore the following aspects: (1) The sinicization of the indicator system. The existing research conclusions on Western cities cannot be fully applicable to Chinese cities, and targeted research needs to be conducted based on the characteristics of Chinese cities. (2) Reflection on quantitative research. As a result of factors such as data availability, domestic scholars mostly focus on qualitative research on AFEs, lacking empirical and quantitative research results. This study develops an indicator system for quantifying the quality of urban AFEs in China, which not only facilitates a quantitative assessment of the age-friendliness of Chinese urban environments, but also allows for an elucidation of the factors that shape them. We seek to answer the following questions through research: What are the problems in the construction of AFEs in cities? What are the influencing factors of AFEs? How can we improve the quality of an AFE? This study lays a foundation for the improvement of AFEs in China and other developing countries.

## 2. Materials and Methods

### 2.1. Study Area and Data Sources

Liaoning Province is located in the southern part of Northeast China (Figure 1) and has the highest proportion of the aging population in China. The population-aging problem in Liaoning Province is the most typical and prominent in China. The accelerated development of population aging has generated urgent requirements for the construction of AFEs. This study selected 14 prefecture-level cities as research areas to seek effective ways to improve the quality of AFEs in Liaoning Province and to provide a reference framework for actively responding to problems associated with population aging.



**Figure 1.** The study area: (a) China, (b) Liaoning Province, and its 14 prefecture level cities.

Research data were obtained from the Liaoning Provincial Statistical Yearbook, China Civil Affairs Statistical Yearbook, and statistical yearbooks of various cities for the period 2010–2023. In addition, data were obtained from the Office of the Liaoning Provincial Aging Work Committee and relevant information consultation service centers of the Liaoning Provincial Bureau of Statistics. For missing data, inverse distance weight interpolation was used.

### 2.2. Construction of the Indicator System and Description of Indicators

#### 2.2.1. Construction of the Indicator System

In 2007, WHO released the Global Age Friendly Cities Guide (hereinafter referred to as the WHO Guidelines) based on a survey of 33 cities in 22 countries worldwide. The WHO Guidelines identified suitable cities for the elderly from the perspectives of the elderly and service providers for the elderly. The main characteristics of cities for the elderly involve eight domains, which reflect the important role of physical conditions, social environment, and public services with respect to the physical and mental health of the elderly. These eight domains can be summarized into three levels, as follows: (1) Physical environment, including outdoor spaces and buildings, transportation, and housing; (2) social environment, including social participation, respect and social inclusion, and civic participation and employment; and (3) public services, including communication and information and community support and healthcare services (see Figure 2). The WHO initiative has spread rapidly and gained global recognition. However, scholars have also proposed that, as a concept, an AFE may be generally beneficial, but specific standards and methods may vary depending on variations in culture and society [37]. The guideline layer of the indicator system in this article adopts the policy framework of the WHO guidelines, which makes the research suitable for international comparison. The selection of indicators considered China's demographic and policy conditions, data availability, and relevant research from scholars [38,39]. Finally, an age-friendly city evaluation indicator system suitable for Chinese cities was designed (Table 1).

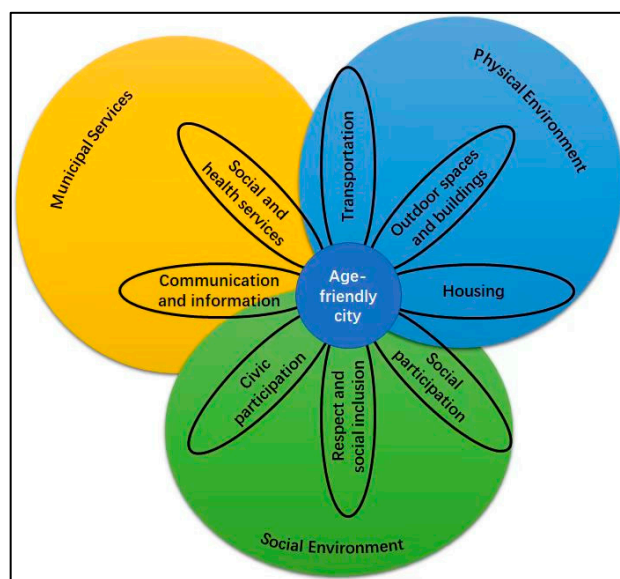


Figure 2. Domains of an age-friendly city [40].

Table 1. Indicator system for the evaluation of age-friendly cities.

Criterion Layer	Indicator Layer	Indicator Attribute
Social environment	X <sub>1</sub> Number of elderly associations	+
	X <sub>2</sub> Number of universities for the elderly	+
	X <sub>3</sub> Number of elderly activity stations/centers/rooms	+
	X <sub>4</sub> Urban unemployment rate	–
Physical environment	X <sub>5</sub> Proportion of days with good air quality	+
	X <sub>6</sub> Per capita greenspace area	+
	X <sub>7</sub> Per capita urban road area	+
	X <sub>8</sub> Bus ownership per 10,000 people	+
	X <sub>9</sub> Per capita living area	+
Municipal services	X <sub>10</sub> Basic medical insurance coverage rate	+
	X <sub>11</sub> Expenditure for basic pension insurance fund for urban and rural residents per elderly person	+
	X <sub>12</sub> Number of beds in medical institutions per thousand people	+
	X <sub>13</sub> Coverage rate of comprehensive service facilities in urban communities	+
	X <sub>14</sub> Proportion of access to internet broadband for users	+

### 2.2.2. Description of Indicators

China has a large elderly population, making the construction of AFEs a necessity. However, it is unrealistic to plan cities or rebuild urban infrastructure according to the livable needs of the elderly. The construction AFEs in most cities in China is optimized based on existing facilities; therefore, the selection of indicators needs to be rooted in a Chinese context. In China, considering regional differences and the implementation of various policies by local governments, the construction of livable environments for the elderly is primarily based on cities as the basic units for policy formulation. Therefore, this study selected the urban scale to construct an indicator system.

- (1) Social Environment (SE). Human beings are governed by social relationships, and sociality is an essential attribute for their wellbeing. Scholars believe that the social environment provides opportunities for the elderly to gather and interact with others [41]. Based on the actual situation in China, an elderly association (X<sub>1</sub>), elderly university (X<sub>2</sub>), and elderly activity center (X<sub>3</sub>) can provide convenient specialized places for the elderly to participate in social activities [42]. The WHO guidelines also

- emphasize employment, and, hence, we chose the urban unemployment rate ( $X_4$ ) to measure the status of employment opportunities for the elderly.
- (2) Physical Environment (PE). In terms of evaluating the physical environment, both Chinese and other researchers have emphasized air quality as air pollution increases the risk of death for the elderly [43,44]. WHO believes that having a large area of green space is one of the most essential conditions for being a friendly city for the elderly, as it provides space for physical activity and social interaction among them [45]. We selected the proportion of days with good air quality ( $X_5$ ) and per capita greenspace area ( $X_6$ ) to measure the quality of outdoor space. In terms of transportation, which is a prerequisite for the elderly to connect with society, it is essential to have a relatively free passage and commute to a desired location. Unlike the Western elderly, who use cars more frequently, the main modes of transportation for the Chinese elderly are public transportation and walking. Many cities stipulate that the elderly over the age of 60 can enjoy preferential or even free public transportation, which has attracted a large number of the elderly to public transportation. Therefore, this study selected the per capita urban road area ( $X_7$ ) and number of buses per 10,000 people ( $X_8$ ) to measure access to urban transportation. In terms of housing, WHO believes that appropriate housing contributes to a healthy aging population, emphasizing the importance of preventing overcrowding. In the context of urban growth, insufficient living space is not conducive to the health of the elderly [45]. Based on data availability, we chose per capita living area as the indicator ( $X_9$ ). There is an intimate link between the physical environment and social environment. For example, urban greening can provide spaces that facilitate physical activities and social interactions of the elderly, with square parks being an excellent example of spaces that meet the social and entertainment needs of the elderly [46].
- (3) Municipal (public) service (MS). During the aging process, the physical abilities of the elderly gradually decline, and the risk of various acute and chronic diseases increases. Accordingly, medical expenses and demand for public health services increase significantly. To measure healthcare services, we chose the coverage rate of basic medical insurance ( $X_{10}$ ), expenditure for basic pension insurance fund for urban and rural residents per elderly person ( $X_{11}$ ), and number of beds in medical institutions per thousand people ( $X_{12}$ ) as indicators. As the physical capacity of the elderly decreases, the range of distance for outdoor activities becomes much smaller than that of young people. Communities and families have become the primary care areas for the elderly [47]. Comprehensive community service facilities are of great significance for meeting the diverse service needs of the elderly. The coverage rate of comprehensive service facilities for the urban community ( $X_{13}$ ) was chosen to measure community support. Information and communication technology is spreading globally at an unprecedented rate, significantly impacting all areas of daily life of the elderly [48]. In 2015, WHO released a set of core indicators to measure the age-friendliness of cities, including internet access. Therefore, the proportion of internet broadband users ( $X_{14}$ ) was chosen to measure the information support provided by cities for the elderly during this information age.

### 2.3. Methods

**Entropy method:** We chose this method because of its ability to overcome the drawbacks of overlapping information between indicator variables and the subjective influence of manually determining weights. We calculated the difference coefficient of the evaluation indicators using the entropy method and then defined the weights of the evaluation indicators. Based on the weights and standardized values of the evaluation indicators, the values of the quality of AFEs were calculated and the characteristics of spatial patterns were analyzed using ArcGIS 10.6 software.

**Multiple linear regression analysis:** an AFE is a complex system, and its influencing factors have characteristics such as diversity and complexity. It is necessary to reflect changes

in the dependent variable through multiple independent variables [49]. Therefore, we adopted a multiple linear regression analysis. The multiple linear regression model is as follows:

$$Y = a + b_1X_1 + b_2X_2 + \dots + b_nX_n \quad (1)$$

where  $a$  is a constant term and  $b_1$ – $b_n$  are the regression coefficients,  $X_1$ – $X_n$  are the independent variables, and  $Y$  is the dependent variable.

### 3. Results

Using ArcGIS 10.6 software, spatial visualization was conducted on the age-friendly level of cities in Liaoning Province for 2010, 2015, and 2021 (Figure 2). Using the Jenks natural breaks classification method, the age-friendliness level of cities was classified into five levels as follows: very low, low, medium, high, and very high.

#### 3.1. Spatiotemporal Pattern of Age-Friendliness Level

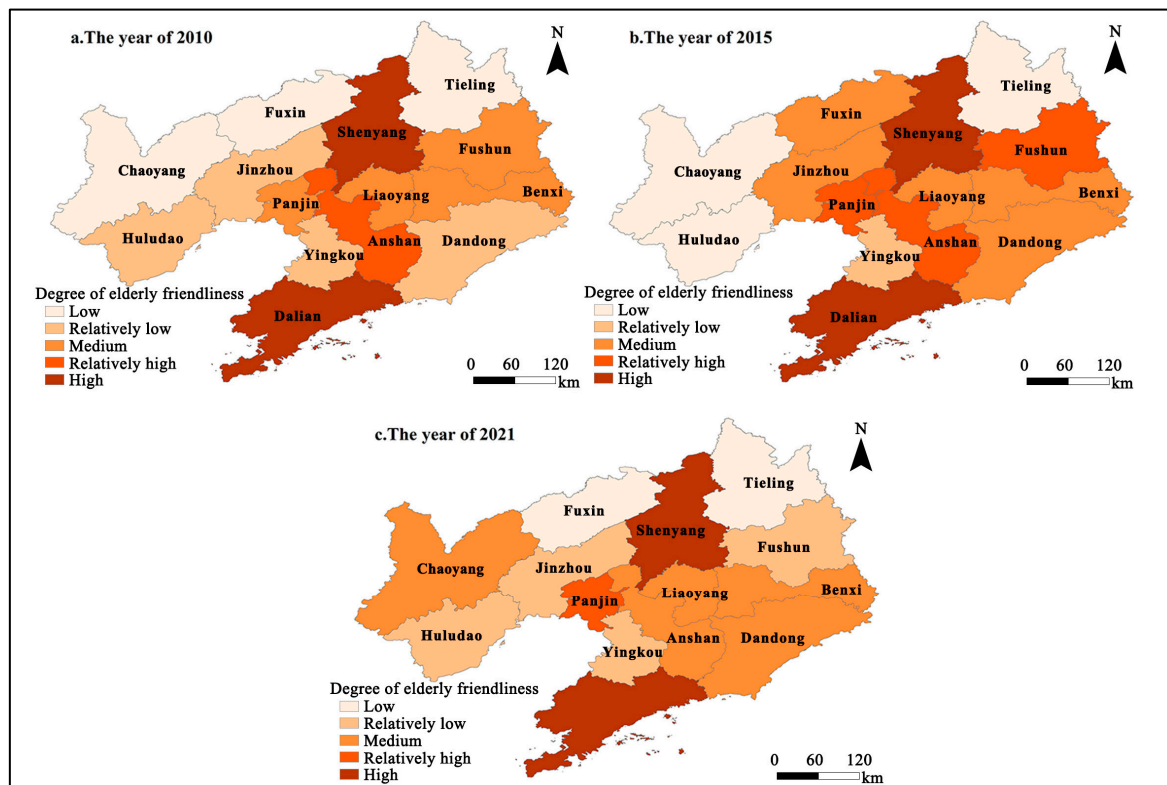
##### 3.1.1. Analysis of Time Evolution Characteristics

On a timescale, the comprehensive quality of AFEs in cities in Liaoning Province is at a relatively low level, and the overall trend is decreasing. In 2010, the average comprehensive quality of the AFEs was 0.3881. The average comprehensive quality in 2015 showed a significant improvement compared with that in 2010 at 0.4065. However, in 2021, the average comprehensive quality decreased sharply to 0.3702, which was the lowest value recorded during the evaluation period, which coincided with the onset of the “new round of Northeast recession”. Owing to the economic downturn, the government’s investment toward the construction of AFEs was limited. Simultaneously, the COVID-19 pandemic noticeably impacted urban construction and development. During the evaluation period, the level of age-friendliness in various cities was low, with a relatively small number of cities scoring higher. There were more cities in the middle and lower levels for age friendliness, with a relatively wide distribution. The overall score ranking of each city exhibited relatively less changes, indicating a strong stability. By calculating the average, standard deviation, and coefficient of difference of age friendliness over the years, it was found that the gap in age friendliness between the cities was constantly narrowing, and the degree of dispersion was decreasing. The coefficient of difference decreased from 0.404 in 2010 to 0.308 in 2021. The gap in the age-friendliness level between the highest-ranked and lowest-ranked cities decreased from 0.549 in 2010 to 0.420 in 2021, indicating that the spatial differences in the urban age-friendliness level were reduced in recent years, and regional development was balanced. This finding also indicates that various cities showed a certain degree of uniformity and universality in the construction of AFEs.

##### 3.1.2. Analysis of Spatial Distribution Characteristics

On a spatial scale, significant regional differences in the AFEs of the cities in Liaoning Province existed. Spatial variation patterns of “high in the middle and low on both sides” and “strong in the south and weak in the north” were observed (Figure 3). The level of age friendliness in Shenyang and Dalian was high during the entire study period, maintaining a significant and lasting advantage. During the evaluation period, the values of these two cities were significantly higher than those of the other cities, and they were consistently ranked as the top two cities. These cities also had a certain spillover effect on the surrounding cities. High-value areas were mainly distributed in the central and southern city clusters of Liaoning, with Shenyang and Dalian as the core cities, and significant difference between these cities and their surrounding areas were observed. A significant gap in the level of age friendliness between cities in western Liaoning, such as Chaoyang, Fuxin, and Jinzhou, and Shenyang and Dalian continuously existed during the study period, forming a “depression” in the distribution of age friendliness. This is because the level of AFE construction is closely related to the level of economic development. Since the revitalization of Northeast China, the central and southern regions of Liaoning Province gained good development opportunities owing to their superior geographical

conditions and abundant funds for urban construction and public services. However, the western region of Liaoning is relatively underdeveloped, and this economic foundation determines the government's investment in the construction of an AFE, resulting in a different pattern. During the evaluation period, although the level of age-friendliness in various cities changed; the spatial patterns of “high in the middle and low on both sides” and “strong in the south and weak in the north” remain relatively stable. In the process of building an AFE in Liaoning Province, attention should be paid to the coordinated development between cities, and policy support should be more inclined toward cities in the western and northern regions.

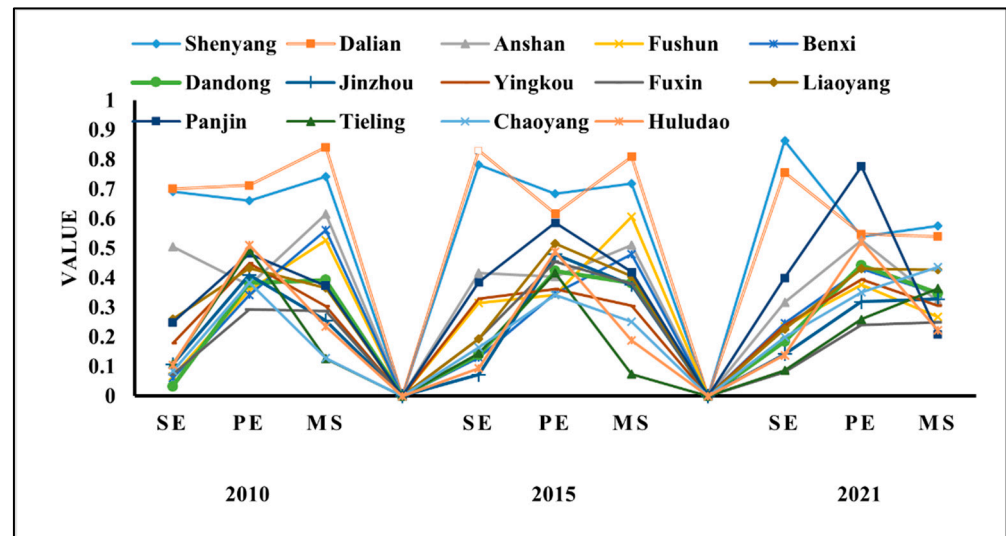


**Figure 3.** Spatial distribution pattern of the level of elderly-friendliness in 14 prefecture-level cities of Liaoning Province in 2010, 2015, and 2021.

### 3.1.3. Analysis of Dimensional Features

The scores of the dimensions of AFEs in cities in Liaoning Province showed significant differences in the following order: physical environment (PE) > municipal services (ME) > social environment (SE) (Figure 4). The social environment was weak in Liaoning Province and needs more attention in the future. In particular, it is necessary to increase the number of elderly universities and activity rooms to provide more opportunities for participation in social activities by the elderly. The standard deviation and coefficient of difference of the physical environment were the lowest at only 0.19 for each, with low differences between cities, whereas the standard deviations of municipal services and social environment exceeded 0.60, indicating significant differences between cities. Shenyang and Jinzhou had the highest and lowest social environment scores of 0.778 and 0.107, respectively, with a difference of 6.3 times between them. In addition, the social environment scores for the cities of Dandong, Fuxin, Tieling, and Huludao were extremely low, and efforts are required to improve them. Dalian and Tieling had the highest and lowest municipal services scores of 0.730 and 0.188, respectively, with a difference of 2.9 times between them. In addition, the scores for municipal services of Chaoyang and Huludao

Cities were extremely low. Liaoning Province needs to implement “precise policies” based on the current situation in each city to improve the quality of AFEs.



**Figure 4.** Evaluation of dimension values for 2010, 2015, and 2021.

### 3.2. Analysis of Factors Influencing the Quality of the Age-Friendly Environment

The dynamics of AFEs are multifactorial. Based on published literature [40,43], the per capita disposable income of urban residents ( $Y_1$ ), expenditure for urban and rural community affairs ( $Y_2$ ), aging rate ( $Y_3$ ), per capita gross domestic product (GDP) ( $Y_4$ ), and general public service expenditure ( $Y_5$ ) were selected as the independent variables. This is because the economy is the foundation of urban construction and the primary means through which citizens can improve the quality of their living environment [50]. Based on this framework, the GDP and per capita disposable income of urban residents were selected as independent variables. China has a large elderly population, and the large-scale construction of AFEs cannot be achieved without government support. We chose general public service expenditure and urban and rural community affairs expenditure as independent variables. The service target of an AFE is the elderly; therefore, the aging rate was selected as the independent variable. The model was constructed using the comprehensive index of AFE as the dependent variable. Multiple linear regression was used to calculate the  $p$  value and standardized beta coefficient in the model, and the differences in the degree of influence of each factor were compared.

A diagnostic analysis was conducted on the collinearity of the model regression using SPSS 19.0. The preselected factors that influence the differentiation of the quality of AFE, except for general public service expenditure, had a variance inflation factor (VIF) of  $<10$ , and a tolerance of  $>0.1$  for all of the other variables. After excluding this factor, a second multiple linear regression analysis was conducted. The results showed that the overall goodness-of-fit  $R^2$  of the model was 0.961, the adjusted  $R^2$  was 0.944, and the  $p$  value of the equation was  $<0.001$ . After testing, it was higher than the degree of influence of each factor, indicating that the overall simulation effect of the model was good and the selected influencing factors were representative (Table 2).

The results of the regression analysis show that the aging rate was negatively correlated with the level of AFE, whereas per capita GDP, per capita disposable income of urban residents, and expenditure for urban and rural community affairs were positively correlated. According to the value of the regression coefficient, they were ordered as follows: expenditure for urban and rural community affairs  $>$  per capita GDP  $>$  per capita disposable income of urban residents.

The impact of expenditure for urban and rural community affairs on the level of the AFE was the most significant, with a standardized regression coefficient of 0.587, which



is a significant positive correlation because the community is the main space in which the elderly live, and the construction of an AFE relies on strong government investment. The greater the expenditure on urban and rural community affairs, the more capable the community is in providing an AFE.

**Table 2.** Multiple regression coefficient analysis of the factors underlying the age friendliness of an environment.

	Non-Standardized Coefficients		Standardized Coefficient	t	Significance
	B	Std. Error	Beta		
Constant	0.215	0.022		9.782	0.000
Y <sub>1</sub>	1.443	1.242	0.233	1.163	0.001
Y <sub>2</sub>	3.814	0.000	0.587	5.733	0.000
Y <sub>3</sub>	−0.223	0.133	−0.116	−1.679	0.003
Y <sub>4</sub>	1.858	1.097	0.287	1.693	0.000

The impact of per capita GDP on the level of AFE is significant and shows a significant positive correlation with a standardized regression coefficient of 0.287. Per capita GDP reflects the level of economic and social development of a city and is also the economic foundation for building an AFE. The results show that cities with a higher level of AFE in Liaoning Province had a higher level of economic development. Developing an urban economy is an important prerequisite for creating a high-level AFE.

The per capita disposable income of urban residents had a significant impact on the level of the AFE, showing a positive correlation with a standardized regression coefficient of 0.233. People make up the main body of the living environment and are the fundamental driving factors for improving the quality of the living environment. The increase in the disposable income of residents can increase their demand for a high-quality AFE with continuous improvement.

Aging rate has a significant impact on the level of AFEs, showing a negative correlation with a standardized regression coefficient of −0.116. An increase in the number of elderly will create strong pressure on urban resources and public services for elderly care, thereby reducing the average level of the quality of urban AFEs.

## 4. Discussion

### 4.1. Construction of the Indicator System

Based on the theoretical framework of the WHO and China's demographic and policy conditions, an urban-scale indicator system for the evaluation of AFEs was constructed by considering the dimensions of social environment, physical environment, and municipal services. The indicator system reflects the general principles of the WHO guidelines by comprehensively considering conditions specific to China, thereby allowing for it to be contextually useful, specifically, in terms of facilitating an objective evaluation of the age-friendliness of Chinese cities. This approach is a move toward meeting the needs of China's aging population. However, the items on the World Health Organization's list of AFEs are designed based on developed countries, and many of its outlined indicators are not congruent with the dynamics of many developing countries [35,51,52]. Therefore, we realized the need for framing AFEs in terms of policies of developing countries in a non-Western context. This approach should enrich research on AFEs and help promote the concept of age friendliness across the globe.

### 4.2. Limitations

Given the complexity of the evaluation of age-friendly cities and the limitations of data acquisition, the construction of the indicator system is not sufficiently comprehensive. In the future, this limitation can be overcome by further data acquisition and expanding the scope of the analysis to other urban regions.

### 4.3. Recommendations

The construction of and research on AFEs is beneficial to the international community with respect to overcoming the challenges of aging. In the context of accelerated population aging, exploring effective ways of creating AFEs has great practical significance. Based on this research, the following suggestions are proposed.

First, cities in Liaoning Province need to strengthen the construction of a livable environment for the elderly and increase expenditure on urban and rural community affairs. As the social environment is weak in Liaoning Province, it needs attention in the process of construction of AFEs. In particular, it is necessary to increase the number of universities and activity rooms for the elderly, thereby providing more opportunities for their social participation. In cities with insufficient financial resources, it is possible to pay the elderly within the range that is acceptable to them. In terms of spatial facilities, it is possible to cooperate with other educational institutions in the city, such as educational institutions for children, and to use them in stages to fully utilize idle resources.

Second, targeted efforts should be conducted to build AFEs considering the differences in economic and social development levels among regions. In cities with lower levels of economic development, the government should increase investment and focus on improving the quality of the material environment and public service. In economically developed cities, the government should increase efforts to build soft services, such as social services and cultural environments, while ensuring that the AFE is maintained at a high level.

Third, the coordinated development of different regions is necessary. Shenyang and Dalian have obvious advantages in terms of providing an AFE; hence, they can play a leading role in promoting the AFE to other cities through experience sharing and paired assistance. Key attention and support are needed for the low-level regions of AFEs, such as the cities of Chaoyang, Fuxin, and Jinzhou. Attention should be paid to coordinated development between cities. Relevant policy support is required for cities in the western and northern regions for the progress of constructing AFEs in Liaoning Province.

The main value of this research lies in its ability to provide a theoretical basis and practical support for the formulation of reasonable policies for the construction of AFEs in Chinese cities. China is a developing country, and its challenges in the construction of AFEs in Chinese cities are representative of its development. The problems highlighted through this paper and the proposed countermeasures should help with explaining and solving similar problems in other developing countries. In addition, it is worth noting that the connotation of AFEs is complex, including the city and residential and working environments. In the context of the aging population, many countries are adopting policies to delay retirement to avoid the collapse of the elderly care system [53,54], which enables an increasing number of elderly people to contribute to the workplace. Therefore, it is necessary to adapt the work environment to the elderly.

## 5. Conclusions

Based on a combination of a theoretical framework from the World Health Organization and China's demographic and policy conditions, an urban scale evaluation index system for an age-friendly environment (AFE) was constructed. Its construction was rooted in a consideration of the social and physical environments and municipal services. The entropy method and multiple linear regression were used to study the changes and factors underlying the quality of AFE in 14 prefecture-level cities in Liaoning Province.

First, on a timescale, the comprehensive quality of AFE in the cities in Liaoning Province was relatively low, and its trajectory, overall, showed a decrease. During the evaluation period, the level of age friendliness across various cities was generally low, with relatively few cities having high scores. There were more cities in the middle and lower levels for age friendliness, with a relatively wide distribution. This indicates that the vast majority of cities were not yet fully prepared for China's rapidly aging population, warranting the implementation of solutions to urgently address this issue.

Second, on a spatial scale, there were significant regional differences in the age friendliness of the environment in cities in Liaoning Province. The pattern underlying this spatial difference could be characterized as follows: “high in the middle and low on both sides” and “strong in the south and weak in the north”. The construction of a friendly environment for the elderly could not be achieved with financial capital, government planning, and corresponding policy support. Shenyang, as the provincial capital city of Liaoning Province, and Dalian, as a sub provincial city of Liaoning Province, are highly economically developed, providing a robust foundation for actively responding to the needs of their aging population.

Third, dimensionality characteristics indicated significant differences in the following order: physical environment > municipal services > social environment. The social environment could not support the construction of an AFE in Liaoning Province, necessitating implementation strategies aiming toward strengthening it in the future. From the perspective of population development trends, as middle-aged and young people gradually become counted among the elderly during the peak period of aging in the next 20 to 30 years, the education level and cultural importance of the elderly will keep increasing, and the demand for a spiritual and cultural life will also become stronger. Therefore, there is an urgent need to improve the quality of the social environment.

Fourth, the analysis of influencing factors shows that the aging rate was negatively correlated with the level of AFE. In contrast, per capita gross domestic product (GDP), per capita disposable income of urban residents, and expenditure on urban and rural community affairs were positively correlated with the level of AFE. The regression coefficients were sorted in the following order: expenditure for urban and rural community affairs > per capita GDP > per capita disposable income of urban residents. Through the lens of influencing factors, cities in Liaoning Province need to continuously increase their expenditure on urban and rural community affairs to improve the quality of elderly-friendly environments. Simultaneously, these cities also need to adjust population policies in a timely manner to cope with “fewer children” and “aging”.

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