


# Spatio-temporal Analysis of Demand for Elderly Care Services and Its Key Influencing Factors in Chinese Cities: A Web Search Engine Approach

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## Abstract

The demand for elderly care services (DECS) in Chinese Cities is one of the most concerned issues. The aim of this study was to understand the spatial and temporal evolution and external factors of DECS in Chinese cities and support the formulation of elderly care policies. We collected Baidu Index data for 287 prefecture-level and above cities and 31 provinces in China from January 1, 2012 to December 31, 2020. The Thiel Index was employed to describe the differences of DECS at different regional levels, and multiple linear regression was used to explore the external factors affecting DECS by calculating the variance inflation factor (VIF) to identify multicollinearity. The DECS of Chinese cities increased from 0.48 million in 2012 to 0.96 million in 2020, and the Thiel Index decreased from 0.5237 in 2012 to 0.2211 in 2020. Per capital GDP, number of primary beds, proportion of population aged 65 and over, number of primary care visits, and proportion of illiterate population over the age of 15 have significant influences on DECS ( $P < .05$ ). DECS was on the rise in Chinese cities, with significant regional differences. At the provincial level, regional differences were influenced by level of economic development, primary care provision, aging population, educational attainment, and health status. It is suggested to pay more attention to DECS in small and medium-sized cities or regions, to strengthen primary care, and to improve the health literacy and health status of the elderly population.

## Keywords

demand for elderly care services, Baidu Index, spatial-temporal evolution, elderly care, influencing factors

### What do we already know about this topic?

Most studies explore the demand for elderly care services based on the micro perspective.

### How does your research contribute to the field?

This study further understands the spatial-temporal evolution and influencing factors of the demand for elderly care services based on the Baidu index.

### What are your research's implications toward theory, practice, or policy?

Targeted policies and measures, including focusing on the demand of small and medium-sized cities or regions, strengthening primary care, and improving the health literacy and health status of the elderly population, so as to improve the accessibility of elderly care services and quality of life of the elderly.

## Introduction

Population aging is one of the most significant demographic characteristics in the world, which makes the provision of elderly care and health care services a great challenge. According to the results of World Population Prospects 2022,

9.6% of the world's population was over 65 years old in 2021, and it is projected to account for 16.5% of the total population by 2050.<sup>1</sup> China's seventh census shows that the proportion of people aged 65 and over in the total population was about 13.8% in 2020<sup>2</sup> and is expected to reach about 30% by 2050.<sup>1</sup> The continued growth in the quantity and



proportion of older people puts greater pressure on the elderly care system.

Demand for elderly care services (DECS) is at the core of elderly care issues, and with the increasing aging of the world's population, research on DECS has received increasing attention. Currently, most research on DECS has been conducted from the perspectives of health,<sup>3</sup> demographics,<sup>4</sup> economics,<sup>5</sup> and sociology.<sup>6</sup> With the application of geography in aging research, many scholars have explored the differences in the spatial and temporal patterns of DECS and their influencing factors, including urban-rural differences and regional divisions.

At the temporal scale, studies pointed that the demand for long-term care (high-need care) in regions such as the Netherlands,<sup>7</sup> Asia,<sup>8</sup> and the United States<sup>4</sup> was expected to grow rapidly in the coming decades. A study conducted in China found that demand for community elderly care services was on the rise, with the highest demand for health care services and the most significant upward trend in demand for life care services.<sup>5</sup> At the spatial scale, studies on DECS have covered different scales ranging from household—community—township—county (city, district)—provincial—inter-regional—national. Some community-level studies have found that older people in affordable housing communities had higher demand for various community care services than people in commercial housing communities in China.<sup>9,10</sup> Some regional-level studies have found significant differences in unmet long-term care demand between rural and urban China.<sup>11</sup> Jiang et al<sup>12</sup> found that DECS for the disabled elderly was higher in the central and western regions than in the eastern regions.

In spite of growing scholarly attention, 2 key research gaps remain. First, despite increasing efforts to explore the influencing factors on DECS, most studies thus far have taken older people's own characteristics as the independent variables,<sup>13-15</sup> while fewer have focused on external factors and examined the influencing factors from the perspective of regional differences. Shan et al<sup>16</sup> analyzed the DECS in different regions of Wuhan, China, and found that the demand was influenced by regional differences, with older people in new urban areas requiring more training, education and security services than those in central urban areas, which was related to economic status, education attainment, living environment and quality of elderly care facilities. The second key research gap is that fewer studies have been conducted based

on web search engine data, which could overcome the problems of incomplete group coverage and high labor and time consumption associated with traditional survey methods. Hanxiang et al<sup>17</sup> used the Baidu Index to obtain data on social concern of pension service models from 2010 to 2016, and found that the social concern was increasing, and there were significant provincial and regional differences. However, the study only included 3 keywords and did not consider factors such as regional economic levels and the construction of elderly care facilities in the regression analysis.

Therefore, it is vital to explore the spatial and temporal changes in DECS and to further analyze the impact of regional economic development and facility construction conditions on DECS. In recent years, the rapid development and popularity of the Internet has propelled it to become an indispensable part of residents' lives. According to the 49th Statistical Report on China's Internet Development, the number of netizens in China reached 1.032 billion and the overall internet penetration rate reached 73.0% at the end of 2021.<sup>18</sup> However, the substitution of search engine data for DECS has the underlying assumption that search frequency increases simultaneously with demand in the region, which means that residents will only search when there is a relevant demand from themselves, friends or relatives, even if there are some exceptional factors. For instance, people may search for the relevant demand of a friend or relative who does not live in the search area, or the demand of the same person may be searched by different people at the same time. Under this assumption, the more significant the linear correlation between increased search frequency and increased demand, the better the Baidu Index is considered as a substitute for demand.<sup>19</sup> This assumption is not uncommon in some studies based on web search engine methods. Currently, many studies have been conducted based on data from search engine portal, which provide new perspectives in the study of tourism geography,<sup>20</sup> social opinion<sup>21</sup> and housekeeping needs.<sup>22</sup> Also, existing studies have shown that data from search engine portals can reflect the characteristics of residents' demand to a large extent, especially in the analysis of time changes and the horizontal comparison of demand.<sup>20,23</sup> Therefore, the web search engine data can be used to measure DECS in this study. This study aims to: (1) analyze the spatial and temporal trends in DECS in Chinese cities, and (2) explore the impact of inter-provincial differences on DECS from the perspective of regional differences.

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**Table 1.** The Explanatory Variables of the Spatial-Temporal Differentiation of Demand for Elderly Care Services Measured by Baidu Index in China.

Factor	Number	Explanatory variable
Supply	$X_1$	Per capital GDP (yuan)
	$X_2$	Expenditure on civil affairs (welfare for the elderly) per 10000 population aged 65 and over (million yuan)
	$X_3$	Proportion of tertiary industry in GDP (%)
	$X_4$	Number of beds in elderly care services per 10000 population aged 65 and over (per unit)
	$X_5$	Number of primary beds per 10000 population (per unit)
Demand	$X_6$	Proportion of population aged 65 and over (%)
	$X_7$	Number of primary care visits per 10000 population (per unit)
	$X_8$	Proportion of illiterate population over the age of 15 (%)
Control variable	$X_9$	Number of web pages (million)

Note. Data is derived from provincial level data from 2014 to 2020.

## Materials and Methods

### Study Area

As defined in the administrative divisions of the People's Republic of China, there are a total of 31 provinces and 297 prefecture-level and above cities in mainland China. To ensure spatial continuity, only 287 cities at prefecture-level and above were selected as the research objects by removing cities with inconsistent time series or lack of data.

### Data Collection

**Dependent variable.** In this study, we chose DECS measured by the Baidu Index as the dependent variable. Baidu is the largest search engine portal in China, with a market share of 85.5% in China in 2021. The Baidu Index is an evaluation of keyword search popularity launched by Baidu Corporation (www.baidu.com), which has the advantages of a wide range of sampling and easy to obtain.

Based on the popularity of keywords related to elderly care in the Baidu Index demand map and definition of elderly care services in relevant documents in China, we selected institutional care, community care and home care which were the 3 major types of elderly care,<sup>24</sup> as well as nursing homes, elderly care institutions, intelligent elderly care, elderly care policy, and elderly care industry, which were the 5 most popular search keywords. Data for 8 keywords in the same year for each city were aggregated to measure DECS in the city in a given year. We collected data from Jan 1, 2011, to Dec 31, 2020, and the type was the overall trend (PC + mobile).

**Independent variables.** We explored the factors affecting the spatial and temporal differentiation of DECS in China in terms of both supply and demand sides (Table 1).

On the supply side, Cylus and Al Tayara<sup>25</sup> found that regions with higher levels of economic development had better infrastructure, stronger financial support and higher levels of elderly care services, so 2 economic indicators were chosen to represent supply conditions. At the same time,

elderly care services, which played an important role in driving employment and entrepreneurship,<sup>26</sup> had become an important part of the tertiary industry, so the proportion of tertiary industry in GDP was selected. In addition, nearly 10% of the elderly in China currently chose community or institutional care,<sup>27</sup> so we selected the number of beds in elderly care services per 10000 population aged 65 and over. Also, in the context of hierarchical diagnosis and treatment, primary care institutions were the primary choice for elderly people to seek medical treatment, especially those with chronic diseases,<sup>28</sup> thus the number of primary beds per 10000 population was selected.

On the demand side, the main body of DECS was the elderly, which meant the larger the elderly population, the greater the potential demand, so we selected the proportion of the population aged 65 and above as the characterizing factor.<sup>29</sup> Also, health status had a significant impact on DECS,<sup>30</sup> and many studies currently have chosen to use indicators such as neonatal mortality, maternal mortality, population mortality and average life expectancy to measure the health status of the residents.<sup>31</sup> But there is no unified standard macroscopic indicator to measure the health status of the residents due to the multidimensional and complex nature of health. So given that the independent variables selected for this study were mostly macro variables and that older people with chronic diseases were mostly treated in primary care institutions, the number of primary care visits per 10000 population was taken as the characterizing factor.<sup>32</sup> Besides, Long<sup>33</sup> pointed out that the education attainment was an important factor influencing DECS. And affected by factors such as the level of early socioeconomic development, the current elderly population over 65 years old, who born before 1957, had a lower level of education.<sup>34</sup> Based on this, we selected the percentage of the illiterate population to the population over the age of 15 as the characterization factor.

**Control variables.** Considering that the web attention data obtained based on Baidu Index may be affected by the regional Internet, which meant the higher the level of Internet development, the more frequently residents use the

internet, so we selected the number of regional web pages as a control variable.

## Data Analysis

**Spatial-temporal analysis.** To explore the characteristics of changes in DECS at different spatial scales, we divided the mainland China into 3 major regions and six city levels. The 3 major regions are one of the common geographic classifications, including the eastern, central and western regions. The 2022 China City Business Attractiveness Ranking assesses the development of cities based on five dimensions: business resource concentration, city hubs, human activity, lifestyle diversity and future plasticity,<sup>35</sup> and it divides cities into six city levels: including first-tier, new first-tier, second-tier, third-tier, fourth-tier, and fifth-tier cities.

The Theil Index was first proposed by Theil and Henri.<sup>36</sup> It is an index that measures the degree of inequality between individuals or regions. The higher the Index, the greater the inequality. In this study, the Theil Index was used to analyze the difference in DECS in the region. The basic formula of Theil Index is as follows:

$$T_{pi} = \sum_j \frac{Y_{ij}}{Y_i} \log \left( \frac{Y_{ij}/Y_i}{P_{ij}/Y_i} \right)$$

$$T_{BR} = \sum_j \frac{Y_i}{Y} \log \left( \frac{Y_i/Y}{P_i/P} \right)$$

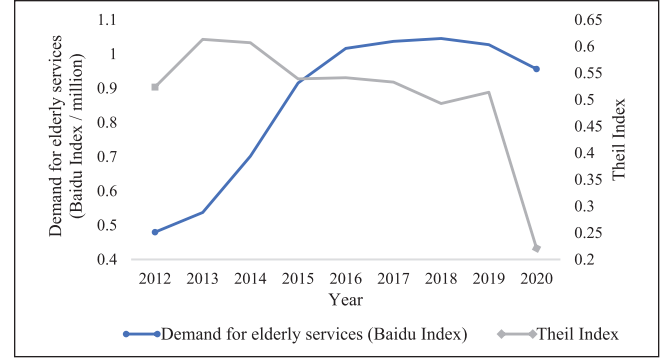
$$T_p = \sum_i \sum_j \left( \frac{Y_{ij}}{Y} \right) \log \left( \frac{Y_{ij}/Y}{P_{ij}/P} \right) = \sum_i \frac{Y_i}{Y} T_{pi} + T_{BR} = T_{WR} + T_{BR}$$

where  $T_{pi}$  represents the intra-regional Theil Index in region  $i$ ,  $T_{BR}$  represents the inter-regional Theil Index,  $T_{WR}$  represents the intra-regional Theil Index after weighting, and  $T_p$  represents the regional Theil Index.  $Y_{ij}$  and  $P_{ij}$  represents DECS and population size of the city  $j$  in region  $i$ , respectively,  $Y_i$  and  $P_i$  represents the demand and population size of region  $i$ , respectively,  $Y$  and  $P$  represents the total demand and the number of the population, respectively.

**Analysis of influencing factors.** Multiple linear regression was used to measure the identification of specific factors that affected DECS. The regression model is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_9 X_9 + \varepsilon$$

where  $Y$  represents DECS,  $\beta_0$  is a constant term,  $\beta_1, \beta_2, \dots, \beta_9$  are the regression coefficient,  $X_1, X_2, \dots, X_9$  are the observed value of the influencing factors in Table 1,  $\varepsilon$  is a random error. Variance inflation factor (VIF) was used to identify multicollinearity for the multivariate regression



**Figure 1.** The demand for elderly care services measured by Baidu Index and Thiel index in Chinese cities from 2012 to 2020.

model. No  $VIF > 5$  was accepted.  $P < .05$  was regarded as statistically significant.

## Data Sources

The data used in this study ( $X_1$ - $X_8$ ) were obtained from the China Statistical Yearbook, China Civil Affairs Statistical Yearbook and China Health Care Statistical Yearbook. Data on the number of web pages ( $X_9$ ) were obtained from the Statistical Report on China's Internet Development published by the China Internet Network Information Center. Due to the lack of data related to elderly care in prefecture-level cities and the change in the statistical category of elderly care institutions in 2014, we only selected data of 31 provinces in China from 2014 to 2020.

## Results

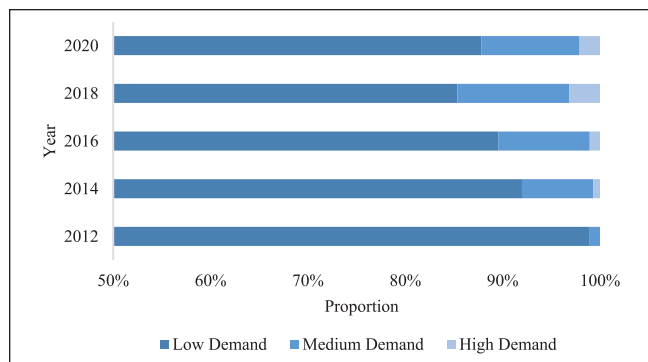
### Characteristics of the Time-Series Evolution

This study measures DECS based on web engine search data. Figure 1 shows DECS measured by the Baidu Index, and Thiel Index from 2012 to 2020. It is shown that DECS in cities above the prefecture level in China was on an upward trend, with regional differences showing a fluctuating decline. It could be divided into 2 stages: the first phase is from 2012 to 2018, a period of rapid growth in DECS in cities, from 0.48 million in 2012 to 1.05 million in 2018, with an average annual growth rate of 13.86%. The regional differences decreased in fluctuations, with the Thiel Index decreasing from 0.5237 in 2012 to 0.4927 in 2018. The second stage is from 2018 to 2020, a period of slight decline in DECS, but still at a high level. The regional differences decreased significantly, with the Thiel Index decreases from 0.4927 in 2018 to 0.2211 in 2020.

### Spatial Differentiation Characteristics

**Overall distribution characteristics.** In order to analyze the spatial distribution characteristics and spatial-temporal evolution





**Figure 2.** Changes in proportion of 3 types of demand for elderly care services measured by Baidu Index in Chinese cities, 2012 to 2020.

process of DECS in Chinese cities, this study conducted a spatial clustering analysis based on data from 2012 to 2020. The K-means distance clustering method was used to classify all samples into 3 type groups, named high level, medium level and low level groups, based on the central values 221997, 86 655, and 9063.<sup>37</sup> ArcGIS 10.8 software was used to visualize 3 types DECS measured by the Baidu Index in Chinese cities.

Figure 2 shows the change in the proportion of demand from 2012 to 2020. It is shown that DECS in cities was mainly of low demand type, and the proportion of low demand cities showed a fluctuating downward trend in 2012 to 2020, from 98.95% in 2012 to 87.80% in 2020. The proportion of medium and high demand cities has increased significantly, indicating that the overall DECS in cities was showing a positive growth trend. The proportion of cities with low, medium and high demand were 87.80%, 10.10%, and 2.09%, respectively in 2020, showing a pyramidal distribution pattern.

In terms of spatial distribution, DECS in Chinese cities showed a spatial distribution characteristic with the central city as the core and gradually spreading to the periphery. Figure 3 shows the spatial distribution of DECS in Chinese cities. It is shown that cities with high demand were mostly national central cities with high levels of economic development such as Beijing, Shanghai, Guangzhou, Shenzhen, Chengdu, and Hangzhou, while cities with medium demand were mainly the more developed cities in the eastern coastal provinces and the provincial capitals in the central and western regions.

**Distribution characteristics among the 3 major regions.** Figure 4 shows average DECS and Theil Index in eastern, central and western China from 2012 to 2020. It is shown that DECS in China was decreasing from east to west. Specifically, the average demand in cities in the eastern, central, and western regions increased from 11.51, 5.48, 3.65 thousand in 2012 to 38.30, 17.54, 14.38 thousand in 2020, with average annual growth rates of 16.22%, 15.64%, and 18.70%, respectively.

Besides, it is shown that the regional differences in demand in 3 regions were decreasing during the study period, with the Theil Index in the eastern, central and western China decreased from 0.3787, 0.4432, and 0.6727 in 2012 to 0.1525, 0.2510, and 0.2629 in 2020, respectively.

**Distribution characteristics of different levels of cities.** According to the 2022 China City Business Attractiveness Ranking, 287 cities can be divided into 6 levels. Figure 5 shows the average DECS in different level of cities in China from 2012 to 2020. It is shown that DECS measured by Baidu Index in 2020 had a distribution characteristic of “first-tier > new first-tier > second-tier > third-tier > fourth-tier > fifth-tier,” with an average of 226.69, 117.09, 52.02, 19.25, 10.67, and 4.30 thousand, respectively. Also, the average annual growth rate of DECS from 2012 to 2020 was 17.91%, 18.03%, 15.38%, 16.79%, 15.69%, and 12.49% respectively.

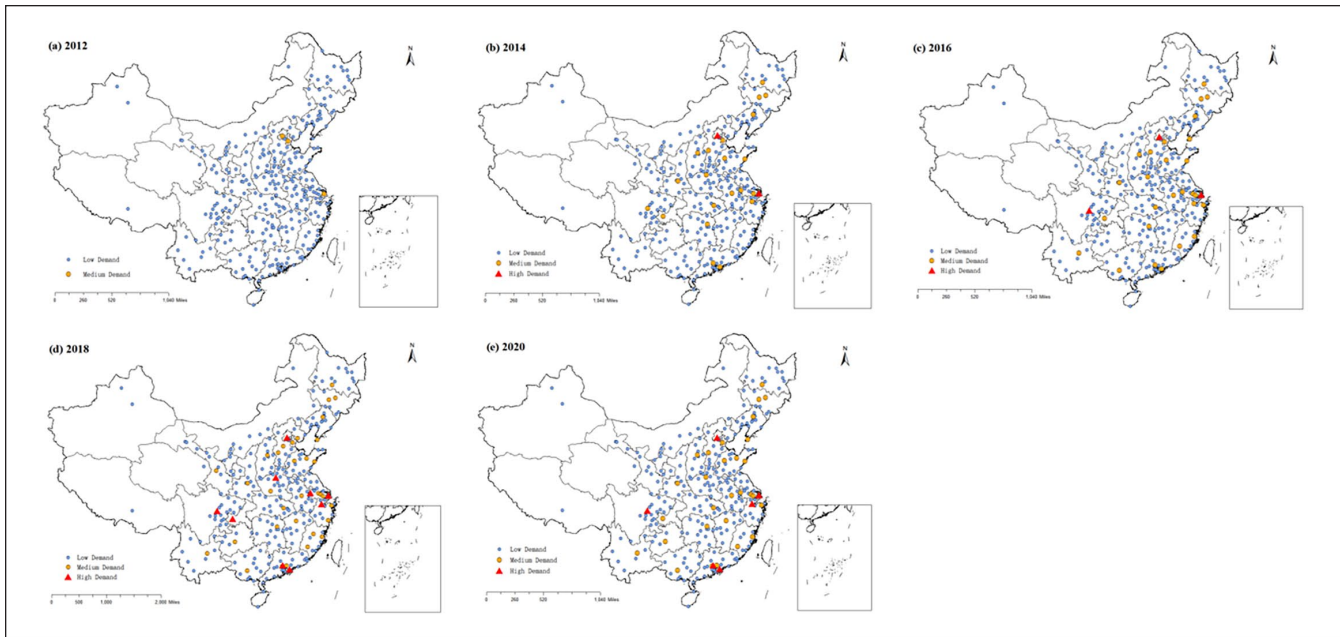
### Influencing Factors

In this study, data of 31 provinces in China from 2014 to 2020 were selected to analyze the key factors affecting the spatial-temporal differentiation of DECS. Table 2 shows the results of regression analysis of factors influencing DECS. The results showed that  $F=96.858$ ,  $P<.001$ , and adjusted  $R^2=.802$ , indicating that the regression equation held and fit well. The highest VIF was 3.595 and the model waived the risk of multicollinearity ( $VIF > 5$ ). On the supply side, the influence coefficients of per capital GDP and number of primary beds per 10000 population on DECS were 0.249 and 0.156. On the demand side, the influence coefficients of proportion of population aged 65 and over, number of primary care visits per 10000 population and proportion of illiterate population over the age of 15 on DECS were 0.353, 0.256, and  $-0.107$ .

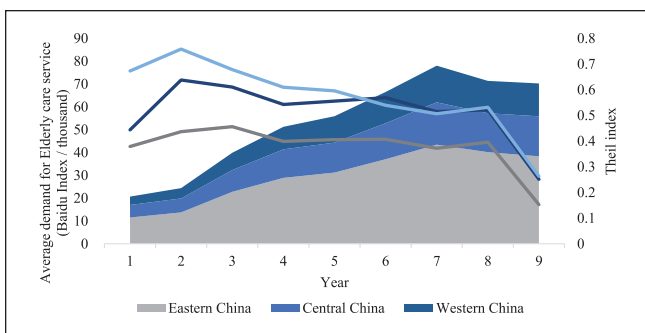
### Discussion

In this paper, we focused on the evaluation of spatial-temporal characteristics and influencing factors of DECS. An assumption was made that searches on Baidu Index for keywords related to elderly care were positively correlated with DECS. The search data were used as outcome indicators for DECS, and these data were able to avoid the disadvantages of difficult data collection and small sampling range.

Our study illustrated that DECS rose rapidly from 2012 to 2018 in Chinese cities, with regional differences showing a downward trend. It may stem from the following reasons: in recent years, population aging in China has accelerated, with the proportion of the elderly aged 65 and above rising from 9.4% in 2012 to 11.9% in 2018.<sup>38</sup> The increases in the absolute number and relative proportion of the elderly have led to an increasing DECS. Meanwhile, the income and consumption level of residents have continued to rise since



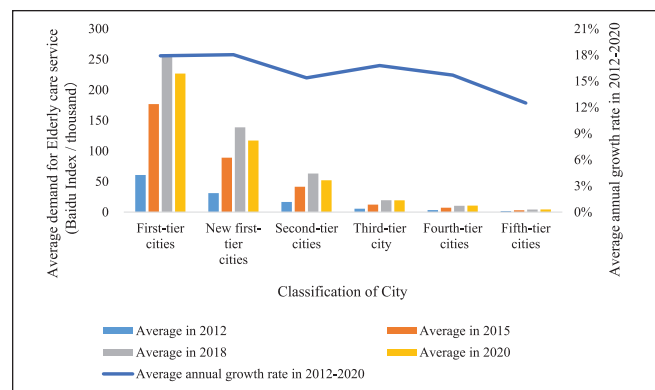
**Figure 3.** Spatial distribution of demand for elderly care services measured by Baidu Index in Chinese cities.



**Figure 4.** Average demand for elderly care services measured by Baidu Index and Theil index in cities in eastern, central and western China from 2012 to 2020.

2012, with per capita disposable income rising from 16668.9 yuan in 2012 to 28228.0 yuan in 2018.<sup>38</sup> The increase in income has contributed to a higher standard of living and a greater concern for the quality of old-age life of residents or their relatives,<sup>39</sup> which has led to an increase in the demand for high-quality elderly care services. In addition, it is shown that the difference in per capita disposable income between regions has been yearly decreasing, and the size of the middle-income group has continued to expand, which may promote the conversion of residents’ potential need into actual demand, and achieve the reduction of the regional differences.<sup>40</sup>

In contrast, DECS declined between 2018 and 2020, but remained at a high level, with a significant decrease in regional differences. This may stem from the impact of COVID-19, with most cities taking measures such as regional



**Figure 5.** Average demand for elderly care services measured by Baidu Index in different level of cities in China from 2012 to 2020.

lockdown, social distancing and restrictions on residents going outside to curb the spread of COVID-19.<sup>41</sup> Also, the World Health Organization stated in mid-April 2020 that up to half of the COVID-19 deaths in Europe occur in long-term care facilities.<sup>42</sup> In this context, residents may pay less attention to public or congregate places such as nursing homes and elderly care institutions, as well as to the elderly care industry, leading to a decline in the Baidu Index of this demand.<sup>43</sup> At the same time, reference found that the main transmission routes of COVID-19 were direct transmission, aerosol transmission and contact transmission,<sup>44</sup> which meant that cities with a higher level of economic development were more prone to large-scale epidemics due to higher personnel mobility.<sup>45,46</sup> Therefore, the decline in demand in such areas was higher than those with relatively lower levels

**Table 2.** Results of Regression Analysis of Factors Influencing the Demand for Elderly Care Services Measured by Baidu Index.

Variable	Unstandardized Coefficients		Standardized Coefficients			
	B	Std. Error	Beta	t	P	VIF
Constant	-94220.571	27724.974		-3.398	.001	
X <sub>1</sub>	0.735	0.171	0.249	4.299	<.001	3.595
X <sub>5</sub>	3520.028	972.533	0.156	3.619	<.001	1.989
X <sub>6</sub>	11581.269	1488.469	0.353	7.781	<.001	2.215
X <sub>7</sub>	25227.501	3660.454	0.256	6.892	<.001	1.483
X <sub>8</sub>	-1694.436	571.86	-0.107	-2.963	.003	1.415
X <sub>9</sub>	0.024	0.002	0.513	9.792	<.001	2.953

Note.  $R^2 = .810$ , Adjusted  $R^2 = .802$ ,  $F = 96.858$ ,  $P < .001$ ,  $VIF < 5$ .

of economic development, resulting in a significant decline in regional differences and Theil Index.<sup>47</sup>

In the analysis of spatial differences, we found that analysis based on 3 regional and six city-level dimensions revealed significant regional differences in DECS in Chinese cities. Notably, the results of the city-level analysis showed that the trend in DECS was fully consistent with the trend in city rankings, which may be due to the fact that most of the higher ranked cities had a large population and a relatively high level of economic development and disposable income.<sup>38</sup> Also, their residents paid more attention to old age life and retirement planning of themselves or their relatives,<sup>48</sup> which provided sufficient motivation to convert the potential demand into actual demand. Similar to this research, studies from Thailand,<sup>49</sup> Italy,<sup>50</sup> and other regions<sup>13,51</sup> emphasized that the regional differences in elderly care resources should be addressed. Therefore, attention should be paid to regional differences and the demand for elderly care in small and medium-sized cities or regions, and regions should be instructed to take into account factors such as the status of the aging population, the level of economic development and DECS, thus reasonably allocating resources for elderly care resources and satisfying the demand of the elderly.

The results of this study could be applied to highlight external factors that influence DECS, informing health policy makers to better understand the influencing factors on DECS and rationalize elderly care resource allocation. The linear regression model identified 5 factors from both supply and demand sides that were significantly associated with DECS at the provincial level.

On the supply side, the influence coefficients of per capita GDP and number of primary beds per 10000 population on DECS were 0.249 and 0.156, which showed that the level of regional economic development was the main factor affecting the demand. Meanwhile, the number of primary beds per 10000 population was an important indicator of the capacity of primary care. Many studies have shown the positive effects of primary care on the management of mental illnesses such as depression<sup>52,53</sup> and the reduction of avoidable hospital admissions<sup>54</sup> and emergency room visits<sup>55</sup> in older people.

On the demand side, the proportion of the population aged 65 and over, the number of primary care visits per 10000 population and the proportion of illiterate people aged 15 and over are the main factors in DECS. First, the proportion of population aged 65 and over reflected the level of population aging in the region, with DECS further increasing as aging developed, which suggested that attention should be paid to the development of regional aging when conducting aging-related discussions and decision-making. Second, the number of primary care visits per 10000 population was one of the important indicators reflecting the health status of the residents in the region.<sup>56</sup> Older people had relatively low immunity and most of them suffered from various chronic diseases, such as hypertension and diabetes, which required treatment through primary care facilities. Therefore, a large number of primary care visits may imply a relatively low health status of the population, leading to a corresponding increase in demand for primary care services.<sup>32,57</sup> This indicated the necessity to pay attention to the health status of older people and to improve overall health by strengthening primary care, improving chronic disease health management across the life cycle and enriching the spiritual life of older people. Third, consistent with previous study,<sup>58</sup> we found the percentage of the illiterate population over the age of 15, which was one of the important indicators to measure the educational attainment, had a significant negative impact on DECS. For the elderly, Li et al<sup>58</sup> found that the education attainment had a significant impact on their preference and choice of care model. Also, the improvement of education attainment was usually considered an effective way to cultivate the health literacy and health behavior of the elderly in previous studies.<sup>59</sup> And people with lower education attainment may have lower health literacy, which left them with some unrecognized or undiscovered elderly care demand.<sup>60</sup> In addition, studies pointed out that educational attainment played a role in factors affecting the daily life of older people and was associated with psychosocial and biological conditions.<sup>61,62</sup> For the family, studies showed a positive association between children's educational attainment and parents' cognitive health,<sup>63</sup> and the higher education attainment of the whole family, the more attention the residents

attach to their own and their relatives' old-age life, which also had a positive impact on the demand.<sup>64</sup> Therefore, it is important to pay more attention to older people with low levels of education attainment and to those whose children have low levels of education attainment. The publicity and promotion of elderly care policies and services should be enhanced through easy-to-understand words and user-friendly publicity, so that people who were unable to access and understand elderly care policies in the past due to their limited education can pay more attention to their personal or relatives' old age and improve their quality of life.

There are several strengths to our study. First, this study is the first to analyze DECS in prefecture-level and above cities in China. Second, based on existing research, this study incorporated additional search words to measure DECS in a more accurate and comprehensive way. Third, we innovatively included regional economic indicators and provincial indicators related to elderly care in our analysis of influencing factors. The findings will assist policy makers to enhance elderly care by developing policy and initiatives either at the local or provincial level.

This study also has limitations. Most notably, this study was limited to the unique web search engine, Baidu, which was only suitable in China, and the data generated from other low-usage search engines was not assessed in our study. Second, the Baidu Index only represents samples from the population as it is calculated based on the overall searches from regional internet users, which may be skewed toward groups with higher socioeconomic status and higher education attainment. Third, our study may be underestimated, as some important population groups may be left out due to limited or unfamiliar internet access. Fourth, the Baidu Index may suddenly increase with the announcement of pension policies and extensive media coverage. Fifth, because of the difficulty of obtaining data related to elderly care institutions in each prefecture-level city, the regression analysis was conducted at the provincial level. Sixth, this study measured health status with primary care utilization, which may have some biases, although studies have pointed to its validity and plausibility.<sup>32</sup>

Despite these limitations, many studies have shown that search engine data can provide valid information to conduct research on a large scale. This study showed that an increasing number of people regularly use online search engines to seek information related to elderly care, thus web search engine data is an important source for monitoring DECS. In the future, we will compare search engine data and empirical data to combine their strengths and gain insight into the influencing factors of DECS. For example, we can evaluate the reliability and stability of using the Baidu Index to indicate DECS by exploring the linear correlation between the Baidu Index and contemporaneous empirical studies. In addition, we plan to obtain more suitable and detailed data to explore DECS, for example, we can incorporate more keywords or weight keywords according to the importance.

Furthermore, we will further introduce qualitative research methods to obtain more realistic and comprehensive information.

## Conclusion

The study provided evidence that there were regional differences in DECS in Chinese cities. Provincial regional differences were influenced by both the supply side (level of economic development, primary care provision) and the demand side (population aging, education attainment and health status). The outcomes obtained from the study can not only help government sectors to improve the elderly service system, but also provide meaningful references for other developing countries that are experiencing or about to experience elderly care problems.

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## Author Contributions

ZD, BJ, and HM designed the study. BJ led the data analysis and wrote the manuscript. HM, LJ, and GQ participated in the data analysis. LJ, GQ, and ZD participated in the revision of the manuscript. All authors have read and approved the final manuscript.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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## Ethics Approval and Consent to Participate

Ethics approval for this study was not required because it was based on the publicly available data. The study subjects were not directly approached.

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