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Analysis of the Current Situation of Population Aging and Alzheimer's Disease in Shandong Province

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Abstract. With economic development, the global population is growing, and aging is worsening, bringing many diseases. Studying population aging and Alzheimer's can address current demographic shifts. This paper will study the influencing factors of population aging and Alzheimer's disease, which will help to formulate aging response policies and dementia prevention and intervention strategies. Ridge regression is used to study the degree of influence of the factors of population aging, including birth rate, mortality rate, urbanization rate, and per capita GDP. For Alzheimer's, it uses comprehensive and national meta-analyses to tally recent decades' prevalence data, then analyzes by gender and age. The results of this study show that birth rate, mortality rate, urbanization rate, and per capita GDP have an impact on population aging. Birth rate has a weak impact on aging, while mortality has a positive impact on population aging. Urbanization rate and per capita GDP. The number of cases of senile dementia was significantly different by age and gender.

Keywords: Shandong Province; Population aging; Senile dementia; Comprehensive analysis; National meta-analysis.

1. Introduction

As the economy grows, the global population increases, and aging worsens, bringing many diseases [1]. With China's rapid economic growth, its population structure has significantly changed. Despite overall GDP growth, the rate declines as aging deepens [2]. Shandong, China's second most populous province, leads with over 20 million people aged 60 and above, exceeding the national average, and is shifting from moderate to severe aging [3]. As aging intensifies, Alzheimer's cases rise, threatening health and quality of life [4].

At present, the number of dementia patients in China ranks first in the world, and the mortality rate of men is about 22/100000, while the mortality rate of women is much higher than that of men (about 49.9/100000) [5]. Shandong is the largest province with a large number of elderly people, and the number of patients accounts for about 7% of the country. Besides gender, age is also an important risk factor for Alzheimer's disease. The older the age, the higher the proportion of Alzheimer's disease. With the increase in age, the brain changes irreversibly, which damages cognitive functions such as memory and learning [6].

The increase in the elderly population has brought about many social problems. Therefore, it is crucial to clarify the influencing factors and growth trends of population aging and Alzheimer's disease. This paper uses ridge regression to study population aging. The data on Alzheimer's disease research were obtained by a national meta-analysis and comprehensive estimation. Therefore, this paper clarifies the influencing factors and growth trend of population aging and Alzheimer's disease, and aims to contribute to the formulation of aging response policies and dementia prevention and intervention strategies.

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2. Details of the Aging Population in Shandong Province in the Recent Ten Years (2016-2025)

2.1. Data Source and Variable Selection

The data in this article is mainly from the Shandong Statistical Yearbook 2025 of the Shandong Provincial Bureau of Statistics. The data is published by the government, authoritative, true and reliable. All data analysis is based on publicly available statistical data. This study selected the aging rate as the explained variable and recorded it as. The birth rate, mortality rate, urbanization rate and per capita GDP were taken as variables.

2.2. Method

This paper uses population aging level as the explanatory variable and birth rate and mortality as additional explanatory variables. To minimize error, urbanization rate and per capita GDP are included as control variables. First, linear correlations between variables are assessed, followed by ridge regression modeling. Ridge regression addresses multicollinearity, offering robust parameters and strong generalization. An appropriate K value is selected to reduce variable correlation.

2.2.1. Data presentation

This paper examines population aging trends and influencing factors from 2016 to 2025, with data shown in Fig. 1. Fig. 1 indicates that Shandong's birth rate declined rapidly, while the mortality rate rose slightly, and the aging rate increased swiftly from 2016 to 2025. From 2021 to 2022, mortality surpassed birth rates, accelerating population aging.

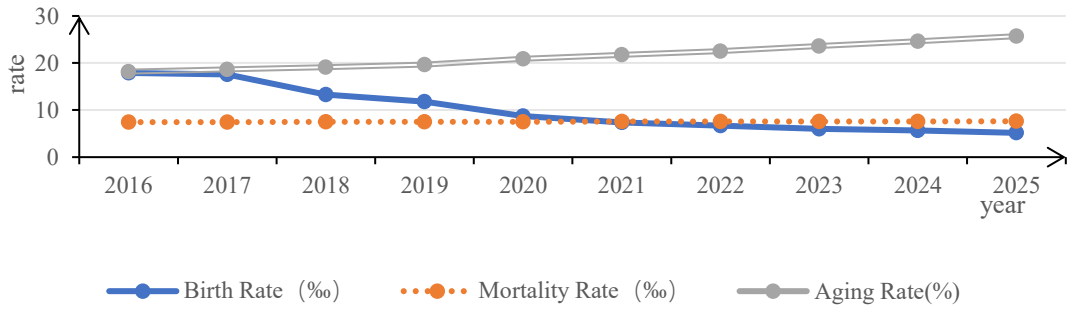

Fig. 1 Population aging rate, birth rate, and mortality rate in Shandong Province from 2016 to 2025 (Photo/Picture credit: Original).

Fig. 2 shows the results of ridge regression analysis with birth rate, mortality rate, urbanization rate, and per capita GDP as variables.

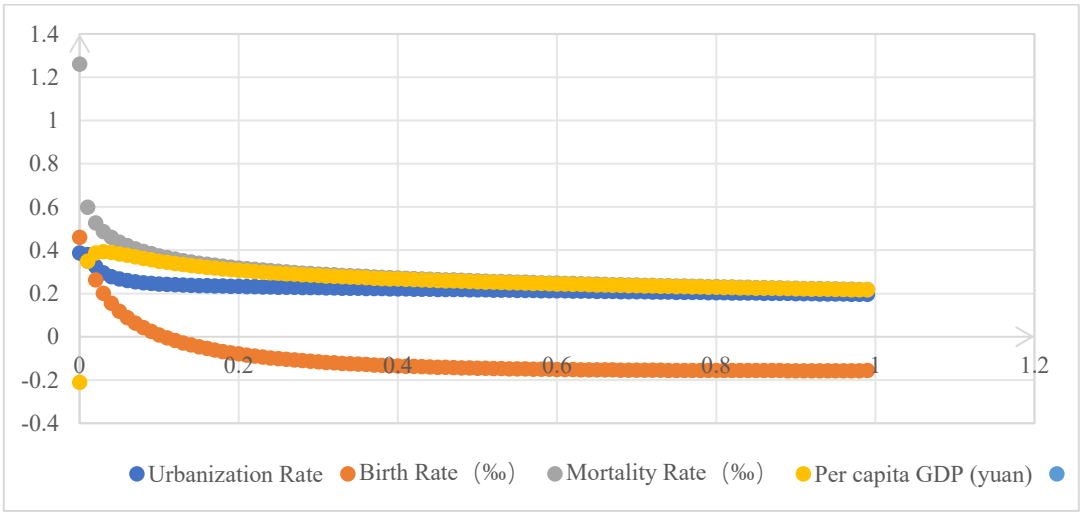

Fig. 2 Results of Ridge Regression Analysis (Photo/Picture credit: Original).

2.2.2. Analysis Results

The best K value is the minimum K value when the standardized regression coefficients of all independent variables tend to be stable. The smaller the K value, the smaller the model deviation. At the same time, we should also consider the multicollinearity of each variable. Therefore, this paper discusses the following two aspects.

Firstly, stability analysis is conducted. The urbanization rate has changed very slowly and tends to stabilize after K=0.04; The coefficient of birth rate (‰) approaches 0 near K=0.10 and turns negative, then slowly changes thereafter; The coefficient of mortality rate (‰) slows down significantly after K=0.01 and gradually becomes flat; The coefficient of per capita GDP (yuan) reaches a peak of 0.393 near K=0.03, and then slowly decreases.

Observing the four coefficients, in the range of K=0.04 to K=0.06, the amplitude of most coefficients has significantly decreased, and the curve has become relatively flat. Choose K=0.05 as the optimal K value. At this point, the model has achieved a good balance between controlling collinearity and maintaining unbiasedness.

Subsequently, a collinearity analysis was conducted. When K=0.00, the maximum VIF reached as high as 360.122, indicating severe multicollinearity. When K=0.01, the maximum VIF decreased to 17.418, still exceeding 10. When K=0.02, all independent variables' VIF values first dropped below 10.

Therefore, the best K value is 0.02. Based on the two analyses, this study opts to employ K=0.05 for the final ridge regression modeling.

Based on Table 2 and the preceding analysis, the ridge plot from ridge regression, with urbanization rate, birth rate (‰), mortality rate (‰), and per capita GDP (yuan) as independent variables and aging rate as the dependent variable (K=0.05), yields the following results: birth rate slightly positively affects aging; population aging positively correlates with mortality; urbanization rate and per capita GDP positively impact population aging. This aligns with existing research and grey correlation analysis, indicating strong correlations among population aging, urbanization rate, and per capita GDP in eastern China [7].

3. Detailed Information on Alzheimer's Disease in Shandong Province Over the Past Decade (2016-2025)

3.1. Data Sources and Algorithm Explanation

No official annual survey data on dementia prevalence by gender and age in Shandong Province was available for 2016–2025. This study employed a national meta-analysis to comprehensively estimate the prevalence by gender and age in Shandong, presented in three-year intervals. Data here is sourced from the 2023 report on Alzheimer's disease prevention and control in China and a systematic review and meta-analysis on its incidence and prevalence in China [8, 9].

3.2. Data Preprocessing

National Meta-Analysis: the data were classified into gender and age (5-year-olds as a group), and the following data processing was performed for each group. The data from the literature mentioned in the previous paragraph are combined by statistical methods.

First, take the total sample size n_i, number of patients x_i from each literature. The prevalence rate p_i can be obtained.

$$p_i = \frac{x_i}{n_i} \tag{1}$$

Secondly, to ensure a reasonable interval, perform a logit conversion on the prevalence of each study.

$$\text{logit}(p_i) = \ln \frac{p_i}{1-p_i} \tag{2}$$

The weights of the random effects model can better reflect this "inter study difference", and the extrapolation of the merged results is stronger. Therefore, a random effects model is adopted, with weights ϖ_i determined by variance:

$$\varpi_i = \frac{1}{\text{Var}(\text{logit}(p_i)) + \tau^2} \tag{3}$$

τ^2 is heterogeneity variance between studies.

$$\text{Var}(\text{logit}(p_i)) \approx \frac{1}{n_i p_i (1 - p_i)} \tag{4}$$

Then calculate the overall logit prevalence rate:

$$\overline{\text{logit}（p）} = \frac{\sum \varpi_i \text{logit}（p_i）}{\sum \varpi_i} \tag{5}$$

Finally restored to the total incidence rate:

$$\bar{p} = \frac{\exp（\overline{\text{logit}（p）}）}{1 + \exp（\overline{\text{logit}（p）}）} \tag{6}$$

A comprehensive analysis shows that the overall standardized prevalence rate can be derived from age- and sex-specific prevalence rates and real population structure via meta-analysis. First, define symbols: gender (male or female) as g, age group (60-64, 65-69,...) as a, meta-analysis-derived prevalence for gender-age groups as p_{ag}, and statistical yearbook population data for these groups as N_{ag}. Afterwards, calculate the number of patients C and the total number of patients TC.

$$C_{ag} = p_{ag} \times N_{ag} \tag{7}$$

$$TC = \sum_{ag} C_{ag} \tag{8}$$

Calculate the total population TP above.

$$TP = \sum_{ag} N_{ag} \tag{9}$$

Finally, the standard incidence rate P is obtained.

$$P = \frac{TC}{TP} \times 100\% \tag{10}$$

N_{Male} : The number of the male population in this group. N_{Female} : The number of females in this group

$$P_{Total} = \frac{N_{Male} \times p_{Male} + N_{Female} \times p_{Female}}{N_{Male} + N_{Female}} \tag{11}$$

p_{Male}, p_{Female} : Corresponding gender prevalence rate (data sourced from national meta-analysis and comprehensive estimation).

Fig. 3 shows the prevalence of dementia in the elderly aged 60 and above in China from 2016 to 2025.

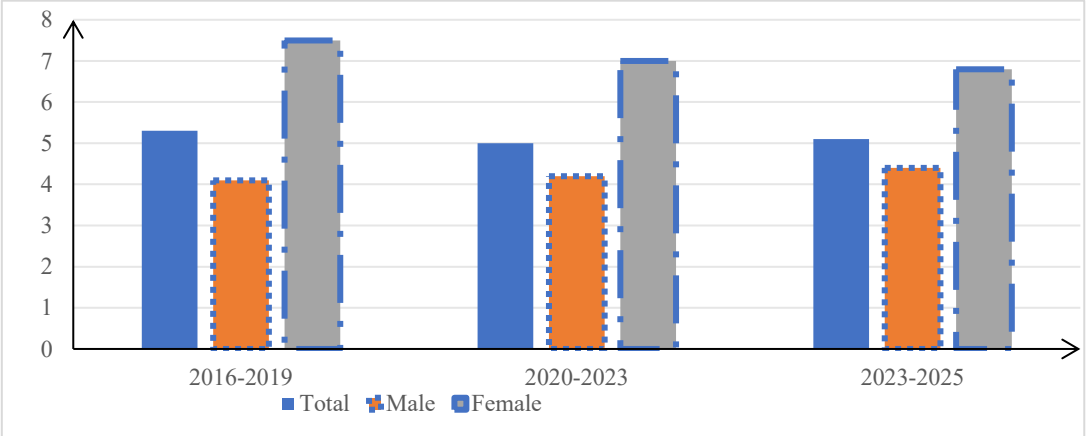

Fig. 3 Gender specific prevalence data of senile dementia in China from 2016 to 2025 (Photo/Picture credit: Original).

Note: The vertical axis represents the incidence rate (%), and the horizontal axis represents the year (year)

Tables 1, 2, and 3 are also divided into three statistical stages. Grouping by gender and age.

Table 1. Age-specific prevalence data of senile dementia (aged 60 and above) in China from 2016 to 2019

Age Group	Total	Male	Female	Gender Differences (Male/Female)
60–64	2.1	1.8	2.4	0.750
65–69	3.2	2.7	3.6	0.750
70–74	5.5	4.7	6.2	0.758
75–79	8.7	7.5	9.8	0.765
80–84	15.3	12.6	17.9	0.704
≥85	30.0	24.5	35.0	0.700

Table 2. Age-specific prevalence data of senile dementia (aged 60 and above) in China from 2020 to 2023

Age Group	Total	Male	Female	Gender Differences (Male/Female)
60–64	1.9	1.6	2.2	0.727
65–69	3.0	2.5	3.4	0.735
70–74	5.2	4.4	5.9	0.746
75–79	8.2	7.0	9.3	0.753
80–84	14.5	12.0	17.0	0.706
≥85	27.5	22.0	32.0	0.688

Table 3. Age-specific prevalence data of senile dementia (aged 60 and above) in China from 2023 to 2025

Age Group	Total	Male	Female	Gender Differences (Male/Female)
60–64	2.0	1.7	2.3	0.739
65–69	3.1	2.6	3.5	0.743
70–74	5.4	4.6	6.1	0.746
75–79	8.5	7.3	9.6	0.754
80–84	15.0	12.3	17.6	0.700
≥85	29.0	23.5	34.0	0.691

3.3. Data Analysis

Gender difference analysis: Among elderly people aged 60-79, males are about 0.75 times more likely to suffer from Alzheimer's disease than females, and males aged 80 and above are about 0.7 times more likely to suffer from Alzheimer's disease than females. Overall, gender has a significant impact on the development of Alzheimer's disease.

Analysis of age differences: The total incidence rate rises significantly with age, particularly between 75-79 and 80-84, and between 80-84 and 85+. Thus, age significantly affects Alzheimer's development, aligning with Yang Huali and Miao Haifeng's study that gender differences and age ≥75 are independent risk factors for malnutrition in Alzheimer's patients [10].

4. Conclusion

In research on Alzheimer's disease, gender and age have a significant impact on the development of the disease. As age increases, the overall incidence rate increases significantly. The male incidence rate is only about 0.7-0.75 times that of females.

This study has certain limitations; for instance, some of the data utilized are not original and thus exhibit a degree of bias. In the future, integrating diverse technologies with big data analytics could further elucidate the influencing factors of aging and Alzheimer's disease, thereby offering more robust scientific support to address the challenges posed by Alzheimer's disease amidst an aging population.

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