Research article

The impact of population aging on the mortality rate of dementia among residents in Suzhou, China, 2004–2023

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Abstract

Background: The global burden of disease research shows that the disease burden of dementia (including Alzheimer's disease and other dementias) is increasing.

Objective: This study aims to analyze the trends of dementia deaths among residents in Suzhou and explore the impact of population aging on dementia mortality rates during the period from 2004 to 2023.

Methods: The study utilizes demographic dementia mortality data of Suzhou's registered residents over the 20-year period for comprehensive analysis. Joinpoint regression analysis was employed to estimate the average annual percentage changes (AAPC) in indicators for dementia. Using the method of decomposing the differences of mortality rates to evaluate the contribution of population aging to dementia mortality.

Results: The population composition ratios of aged ≥60 and ≥65 in 2023 were 25.70% and 20.24%, respectively; The number of dementia deaths from 2004 to 2023 was 24 014, and the average age of death caused by dementia increased from 79.74 ± 11.20 years old to 84.13 ± 8.49 years old. Dementia death age rose significantly over time, varying by gender. The crude mortality rate increased from 14.67/100 000 in 2004 to 21.55/100 000 in 2023, but the standardized mortality rate decreased from 9.16/100 000 in 2004 to 5.91/100 000 in 2023; The increase in the crude mortality rate of residents in 2023 was 213.66% attributed to the contribution rate of population aging.

Conclusions: The overall crude mortality rate of dementia among residents in Suzhou is still on the rise, and population aging is a key factor.

Keywords

Alzheimer's disease, annual percent change, dementia, mortality rate, population aging, trend

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Introduction

Dementia is a syndrome characterized by acquired cognitive impairment such as memory and thinking, which seriously affects patients' daily life, learning, work, and social communication abilities.[1] With the acceleration of the aging process of the population, the impact of dementia on the national health level is becoming increasingly prominent. From a global perspective, the standardized incidence rate, mortality and disability adjusted life expectancy of dementia in China are higher than those in the world, and the overall disease burden is on the rise.[2]

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Scholars predict that by 2050, Chinese dementia patients will account for about 1/4 of the global total.[3] The estimated annual total cost related to dementia worldwide is $1.33 trillion in 2020 and $9.12 trillion in 2050, while China will reach $24.871 billion in 2020 and as high as $1.89 trillion in 2050.[4] Suzhou is located in the central core area of the Yangtze River Delta in China, with a severe aging population. Currently, there is a lack of quantitative evaluation of the impact of population aging on the mortality rate of dementia among Suzhou residents. This study utilizes the population and dementia mortality data of Suzhou residents from 2004 to 2023 to explore the changing trend of dementia mortality among residents, with a focus on analyzing the impact of demographic factors on it, aiming to provide basic data for future healthy aging action plans.

Methods

Data source

Death data comes from the cause of death monitoring data of Suzhou Center of Disease Control and Prevention. This study selects the death data of registered residents in Suzhou from 2004 to 2023. The fundamental cause of death is coded by the International Classification of Disease, the 10th edition (ICD10). The ICD-10 codes used in this study were identical to those in the GBD paper for causes of death. The coding range of dementia is F00-F02.0, F02.8-F03.9, G30-G31.1 and G31.8-G31.9.[3] The population data is sourced from the Suzhou Public Security Bureau.

Quality control

Suzhou City has been piloting population mortality monitoring since 1975 and achieved full coverage throughout the city in 1985. The "Medical Certificate of Death (Inference)" is filled out by qualified practicing physicians trained by hospitals or communities in the population death registration information system. The physician infers the cause of death based on the deceased's medical treatment or family description before death. At the district and county level, there is a dedicated person responsible for reviewing death data item by item. Then, city and provincial Centers of Disease Control and Prevention mortality monitoring specialists regularly inspect the quality of the data, promptly search for the deceased's medical records before death or verify with their families to ensure the completeness and accuracy of the information on the "Medical Certificate of Death (Inference)". Regularly verify data with multiple departments, including public security, civil affairs, and maternal and child health, to fill in gaps and make corrections. At least once every three years, conduct a city wide investigation about omission of deaths, with the omission rate of less than 5%, respectively.

Statistical analysis

Excel 2019, Joinpoint, and R 4.0.4 software were used to sort out and statistically analyze the death data of dementia among registered residents in Suzhou from 2004 to 2023. The population composition, age, mortality, proportional mortality ratio (PMR) and distribution trend of death due to dementia were calculated by sex. The standardized rate adopted Segi's world standard population age composition.[5] A linear regression model incorporating interaction terms between year and gender was used to analyze the differences in time trends. A series of paired t-tests were conducted to examine the gender differences in PMR over multiple years.

To calculate the annual percent change (APC) and average annual percentage changes (AAPC) in indicators, identify significant points of change and compare the differences in trends between different genders, we performed Joinpoint Regression analysis using the Joinpoint Regression Program, Version 4.9.1.0, from the Surveillance Research Program of the National Cancer Institute (Statistical Research and Applications Branch, National Cancer Institute, USA).

Using the method of differential decomposition of mortality rates to analyze the contribution rates of demographic and non demographic factors to the mortality rate of dementia among residents.[6,7] The demographic contribution rate reflects the proportion of mortality change attributable to shifts in population age structure. The non-demographic contribution rate represents mortality changes caused by alterations in exposure to dementia risk factors and unexplained residual factors, excluding population composition). The decomposition was performed using age-specific mortality rates and population proportions across different age groups at two time points. Let CDR^1 and CDR^2 represent the crude dementia mortality rates in 2004 and 2023, respectively, with *diff* denoting the mortality difference between these years. For each age group, C_i represents the population composition and M_i represents the age-specific mortality rate. The mortality difference can be decomposed as:

$$\begin{aligned}\text{Mortality difference } diff = \mathrm{CDR}^2 - \mathrm{CDR}^1 &= \sum C_i^2 M_i^2 - \sum C_i^1 M_i^1 = \sum C_i^2 M_i^2 / 2 + \sum C_i^2 M_i^2 / 2 \\ &- \sum C_i^1 M_i^1 / 2 - \sum C_i^1 M_i^1 / 2 + \sum C_i^2 M_i^1 / 2 - \sum C_i^2 M_i^1 / 2 \\ &+ \sum C_i^1 M_i^2 / 2 - \sum C_i^1 M_i^2 / 2 = \sum C_i^2 \left[\left(M_i^2 + M_i^1 \right) / 2 \right] \\ &- \sum C_i^1 \left[\left(M_i^2 + M_i^1 \right) / 2 \right] + \sum M_i^2 \left[\left(C_i^2 + C_i^1 \right) / 2 \right] \\ &- \sum M_i^1 \left[\left(C_i^2 + C_i^1 \right) / 2 \right] = \sum \left(C_i^2 - C_i^1 \right) \left[\left(M_i^2 + M_i^1 \right) / 2 \right] \\ &+ \sum \left(M_i^2 - M_i^1 \right) \left[\left(C_i^2 + C_i^1 \right) / 2 \right].\end{aligned}$$

The mortality difference can be decomposed as:

$$\begin{aligned}\text{Mortality difference } (diff) = &\ [\text{Effect of age structure differences}] \\ &\times [\text{mean age} - \text{specific mortality rates as weights}] \\ &+ [\text{Effect of other factors}] \times [\text{mean age structure as weights}].\end{aligned}$$

Specifically:

$$\text{Demographic contribution value} = \sum \left(C_i^2 - C_i^1 \right) \left[\left(M_i^2 + M_i^1 \right) / 2 \right];$$

$$\text{Non-demographic contribution value} = \sum \left(M_i^2 - M_i^1 \right) \left[\left(C_i^2 + C_i^1 \right) / 2 \right].$$

The percentage contributions are calculated as: Demographic contribution rate = (Demographic contribution value/*diff*) × 100%; Non-demographic contribution rate = (Non-demographic contribution value/*diff*) × 100%.

Results

Population aging degree

The population composition ratios of aged ≥60 and ≥65 in 2023 were 25.70% and 20.24%, respectively. The result of Pairwise Comparisons within the Joinpoint regression demonstrated significant differences in the population composition ratios of aged ≥60 and ≥65 trend patterns between males and females, with all $p < 0.001$.The joinpoint analysis indicated that from 2004 to 2016, the composition ratios of residents aged ≥60 in Suzhou was in a relatively flat period of 15.57% to 25.02% (APC = 4.4, 95% CI: 3.9, 4.8, $p < 0.001$), however, there was no significant change from 2016 to 2023 (APC = −0.2, 95% CI: −1.2, 0.7, $p = 0.589$). The composition ratios of residents aged ≥65 in Suzhou city showed a steady upward trend from 2004 to 2015, rising from 11.04% in 2004 to 16.68% in 2015, with an APC of 4.1 (95% CI: 3.8,4.5, $p < 0.001$), and a slowly upward trend from 2015to 2023 (APC = 2.5, 95% CI: 1.9, 3.0, $p < 0.001$). Across the entire period, the composition ratios of residents aged ≥60 and ≥65 showed a significant growth trend, with the AAPC of 2.6 (95% CI: 2.2, 3.1, $p < 0.001$) and 3.4 (95% CI: 3.1, 3.7, $p < 0.001$), as shown in Figure 1. Both males and females show an upward trend in the composition ratios of the population aged ≥60 and ≥65, with statistically significant differences (aged ≥60: AAPC = 2.9, 95% CI: 2.4, 3.3 in males, AAPC = 2.5, 95% CI: 2.1, 2.9 in females; aged ≥65: AAPC = 3.8, 95% CI: 3.5, 4.1 in males, AAPC = 3.1, 95% CI: 2.8, 3.4 in females, all $p < 0.001$), indicating that the aging of the population in Suzhou City is increasingly severe from 2004 to 2023.

Average age of dementia death

From 2004 to 2023, there were a total of 24,014 dementia deaths among residents in Suzhou, with an average age increase from 79.74 ± 11.20 in 2004 to 84.13 ± 8.49 in 2023 (AAPC = 0.30, 95% CI: 0.24, 0.37, $p < 0.001$). The mean age at death from dementia among residents in Suzhou was 82.12 years, with males averaging 80.28 years and females 83.24 years. Among them, there were 9

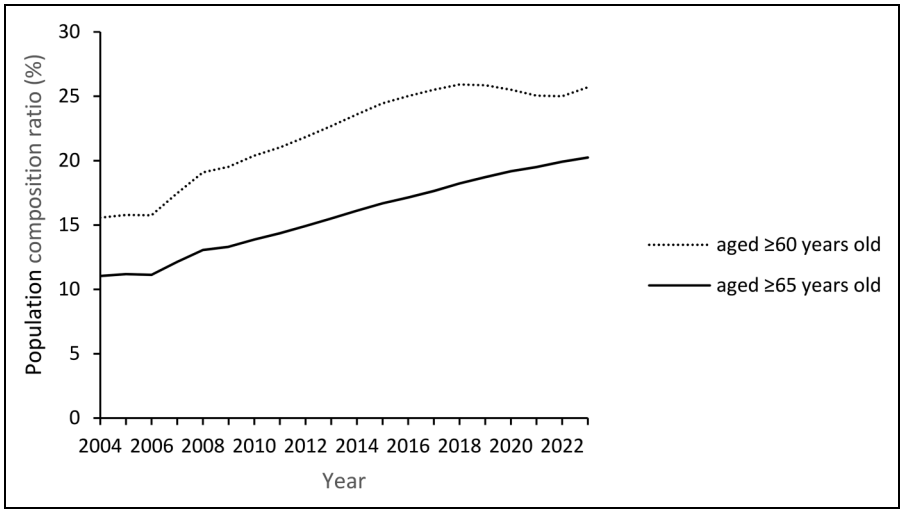

Figure 1. Population composition ratio of aged ≥60 and ≥65 in Suzhou from 2004 to 2023.

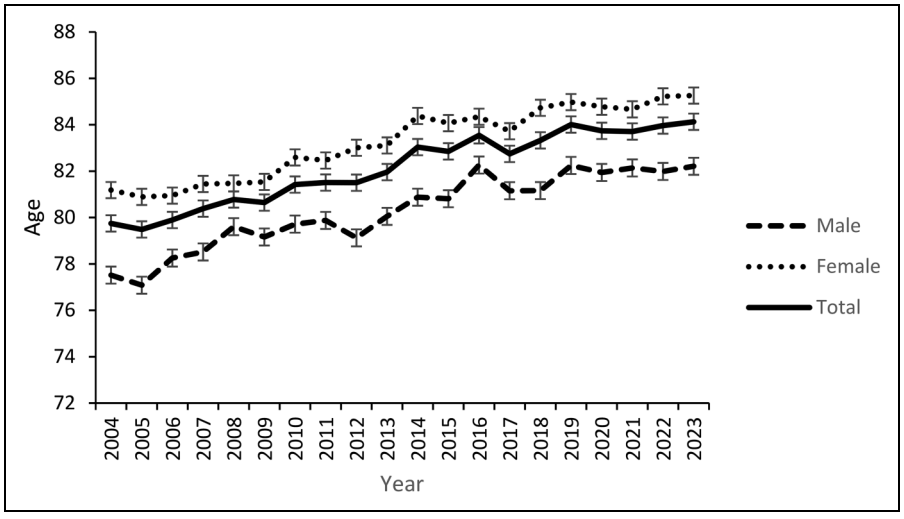

Figure 2. Average age of dementia deaths among residents in Suzhou from 2004 to 2023.

099 males and 14 915 females, with males increasing from 77.52 ± 12.29 in 2004 to 82.21 ± 8.46 in 2023 (AAPC = 0.33, 95% CI: 0.27, 0.39, $p < 0.001$) and females increasing from 81.18 ± 10.20 in 2004 to 85.26 ± 8.31 in 2023 (AAPC = 0.27, 95% CI: 0.16, 0.38, $p < 0.001$). There was a significant increasing trend in the age at death from dementia over time by the linear regression model incorporating an interaction term between year and gender ($T = 5.918$, $p < 0.001$), as shown in Figure 2.

Dementia mortality rate and PMR

From 2004 to 2023, the crude mortality rate of dementia among residents in Suzhou increased from 14.67/100 000 in 2004 to 21.55/100 000 in 2023 (AAPC = 2.92, 95% CI: 2.05, 3.79, $p < 0.001$), but the standardized mortality rate decreased from 9.16/100 000 in 2004 to 5.91/100 000 in 2023, and the trend of change was statistically significant (AAPC = −1.53, 95% CI: −2.37, −0.70, $p < 0.001$). The trend of changes in crude mortality rate and standardized mortality rate is consistent among different genders. The PMR of dementia deaths among residents in Suzhou has increased from 2.22% in 2004 to 2.67% in 2023, and no significant trend of change (AAPC = 1.14, 95% CI: −1.14, 3.47, $p = 0.330$). The PMR of dementia deaths among women is higher than that among men, and the difference is statistically significant ($T = -29.115$, $p < 0.001$). See Figures 3–5 and Table 1 for details.

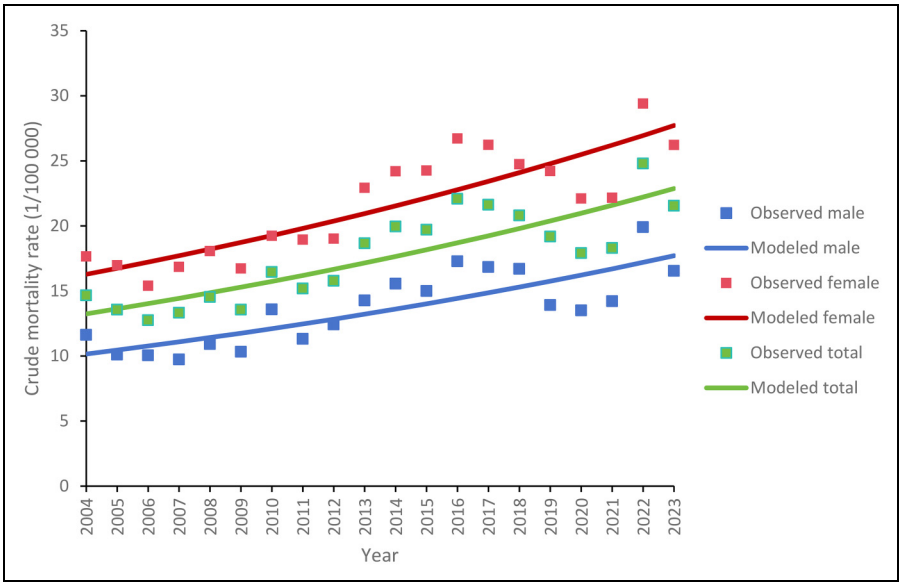

Figure 3. The crude mortality rate in Suzhou from 2004 to 2023.

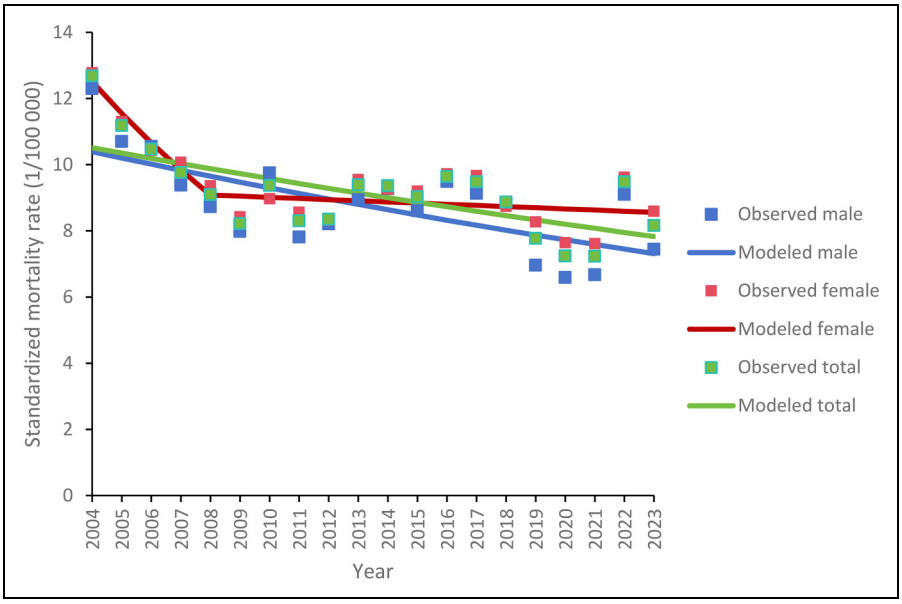

Figure 4. The standardized mortality rate in Suzhou from 2004 to 2023.

Decomposition of differences in dementia mortality rates

The difference in dementia mortality rate between 2004 and 2023 is 6.877/100,000, of which 14.693/100,000 is caused by differences in population age structure, with a contribution rate of 213.66%. In other words, the increase in dementia mortality rate among residents from 2004 to 2023 is due to population aging, with non demographic factors playing a negative role (change value: −7.816/100,000, contribution rate: −113.66%).

Discussion

The World Health Organization defines a country or region as an aging society when the proportion of the population aged ≥65 reaches 7% of the total population, with 10%~15% defined as moderate aging and over 15% defined as severe aging.[8] As early as 2008, scholars predicted that the path of future population aging is the result of a specific combination of declining fertility rates and increased life expectancy in different regions of the world.[9] China is one of the countries with the fastest

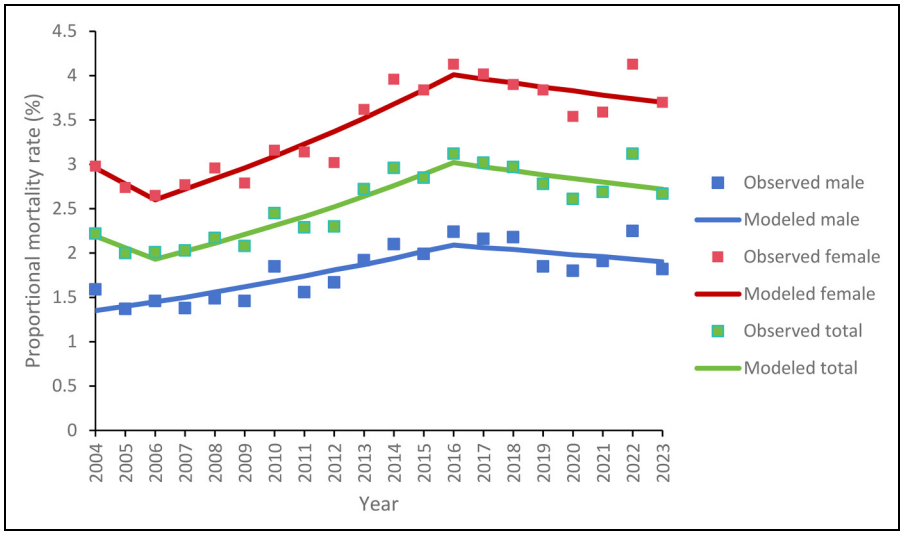

Figure 5. The proportional mortality rate in Suzhou from 2004 to 2023.

Table 1. Joinpoint analysis of mortality rate and proportional mortality ratio of dementia among residents in Suzhou from 2004 to 2023.

	Mortality rate (1/100,000)		2004–2023		Period 1		Period 2		Period 3	
	2004	2023	AAPC (%)	95% CI	Years	APC (%)	Years	APC (%)	Years	APC (%)
Crude mortality rate										
Male	11.63	16.55	2.97*	1.95, 4.00	-					
Female	17.66	26.23	2.84*	2.03, 3.66	-					
Total	14.67	21.55	2.92*	2.05, 3.79	-					
Standardized mortality rate										
Male	8.81	5.31	−1.83*	−2.78, −0.88	-					
Female	9.27	6.26	−1.98*	−3.53, −0.41	2004–2008	−7.69*	2008–2023	−0.40	-	
Total	9.16	5.91	−1.54*	−2.37, −0.70	-					
Proportional mortality ratio										
Male	1.59	1.82	1.84*	0.22, 3.48	2004–2016	3.75*	2016–2023	−1.36	-	
Female	2.98	3.70	1.17	0.94, 3.32	2004–2006	−6.30	2006–2016	4.42*	2016–2023	−1.15
Total	2.22	2.67	1.14	1.14, 3.47	2004–2006	−6.09	2006–2016	4.55*	2016–2023	−1.48

AAPC: average annual percentage changes; APC: annual percent change; * The AAPC/APC is significantly different from 0 at the alpha = 0.05 level;- No joinpoints identified.

aging population in the world. According to the seventh national census data in 2020, the total number of elderly people aged ≥60 in mainland China is 264 million, accounting for 18.7% of the total population.[10] In 2023, the population aged ≥60 and ≥65 in Suzhou will account for 25.70% and 20.24% of the total population, respectively, reaching a degree of severe aging. This indicates that the aging level in Suzhou has a certain representativeness and indirectly reflects the achievements of Suzhou in social and economic development, improvement of medical and health conditions, and other aspects.

The change in dementia prevalence would vary across countries and regions. Globally, dementia incidence statistically significant declined in 18 countries, however, increased in some countries including Japan, China, and so on.[11] A national registry-based cohort study found that there were 165 716 people ≥65 years registered with dementia, 131 321 of whom died in Denmark from 1996–2015, the age-adjusted mortality rate for dementia declined (women: 2.76 to 2.05; men: 3.10 to 1.99).[12] The results of the 2019 Global Burden of Disease Study showed that the standardized prevalence of dementia in China increased by 5.6% from 1990 to 2016, and the global prevalence increased by 1.7%.[13] Foreign research predicts that due to the impact of aging, there were 187 000 dementia patients aged ≥45 in Australia in 2006, but this number is expected to increase to 650 000 by 2051.[14] The standardized mortality rate in the United States increased in two distinct periods: a steep incline from 1999 to 2010 (APC = 6.95, 95%CI: 6.00~7.90), followed by a modest incline till

2020 (APC = 1.41, 95%CI: 0.80~2.04).[15] However, the standardized mortality rate in China slightly decreased from 5.0/100 000 to 4.1/100 000 in 2011–2020.[16] The crude mortality rate and composition ratio of dementia among Suzhou residents showed an upward trend from 2004 to 2023, while the standardized mortality rate showed a downward trend. The difference in standardized death of Alzheimer's disease among residents in neighboring cities shows a downward trend, women are significantly higher than men, which is consistent with our research results.[17] This may be due to the extension of average life expectancy and advances in diagnostic technology,[18] which have led to a sustained growth in the elderly population and an increase in dementia detection rates.

Population attribution studies have found that aging has an impact on disease burden, but the direction and intensity of the impact vary among different countries and diseases.[19] The 2015 Global Burden of Disease Study decomposed the differences in mortality rates from major diseases, and the results showed that population aging led to an increase in deaths from cardiovascular diseases and a decrease in deaths from neonatal diseases.[20] Dementia prevalence in rural China increased over 17 years, while mortality decreased, the major risk factor was aging.[21] This study applied the differential decomposition method of mortality rate to analyze and found that the increase in dementia mortality rate among Suzhou residents from 2004 to 2023 was contributed by 213.66% of the aging population and −113.66% of non population factors. Scholars have reported that an aging population structure may lead to an increase in the mortality rate of elderly dementia in Ningbo, Zhejiang China, with a contribution rate of 300.65%. Changes in other non demographic factors contribute to a decrease in mortality rate by −200.65%.[22]

The global burden of disease research shows that the disease burden of dementia is increasing. However, there are few reports on exploring the changing trends of dementia mortality rate from the perspective of long-term monitoring of the entire population, and the impact of population aging on dementia mortality rate also needs further research. The global prevention and control strategies for dementia are still in the exploratory stage. This study explores the impact of population aging on dementia deaths in residents from a quantitative perspective, providing scientific basis for dementia prevention and control work. However, this study also has certain limitations as it lacks data on the incidence of dementia and exposure to related risk factors, such as individual economic status and lifestyle. In the future, we will gradually expand the scope of data collection using health big data. From 2004 to 2023, dementia diagnosis evolved from reliance on clinical symptoms to a precision medicine model incorporating biomarkers, with the most notable changes occurring in Alzheimer's disease diagnostic criteria.[23] This paradigm shift may have led to underestimated dementia mortality rates in the earlier phase of our study period, representing one of the limitations of this research.

In summary, with the continuous acceleration of population aging in Suzhou, the burden of dementia is increasing. It is necessary to further explore prevention and control strategies for dementia and take corresponding measures to address the challenges brought by aging.

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Ethical considerations

Not applicable

Consent to participate

Not applicable

Consent for publication

Not applicable

Author contribution(s)

Chunyan Huang: Data curation; Writing – original draft; Writing – review & editing.
Linchi Wang: Resources; Supervision.
Lingling Jin: Data curation; Investigation; Project administration.
Wei Fan: Formal analysis.
Huanhuan Zhao: Data curation; Investigation.
Haibing Yang: Supervision; Writing – review & editing.
Yan Lu: Data curation; Formal analysis; Resources; Supervision.
Haitao Wang: Resources; Supervision.

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Declaration of conflicting interests

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

Data availability statement

The data supporting the findings of this research are available within the article.

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