

Why Residents of South China live longer than those of North China?

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Abstract

Background, Since 1990, life expectancy and nonagenarian ratio in South China have been higher than those in North China. Methods, To determine the reason residents of South China live longer, we calculated age-specific mortality rates (per 100,000 people) in North and South China. We examined the associations between the provincial mortality rates due to major fatal diseases and life span indicator. Results, CVD is the leading cause of death in China. The proportion of CVD in all-cause mortality increases with age, and its mortality rate accounts for over 50% of all-cause mortalities in people aged over 80 years. Moreover, the mortality rate of CVD gradually decreases from north to south, indicating the main reason of difference in longevity between North and South China. This difference can be attributed to variations in temperature, salt consumption, selenium intake, air pollution, overweight and obesity between the two regions. Lower mortality rates of individuals aged 55–89 years in South China lead to higher longevity level. Provincial gravity centers of the proportion of longevity population move southward, and this shift is accelerated with increasing age. Conclusions, the mortality rate of CVD gradually decreases from north to south is the reason residents of South China live longer, and risk factors of CVD gradually decreases from north to south.

Background

Life expectancy at birth (defined as the mean number of years remaining at birth until death under specific mortality conditions) and longevity ratio (defined as the ratio of the population above 90 years of age) are currently the main and commonly used lifespan indicators to determine the longevity level^{1,2,3,4,5}.

Beijing and Shanghai are the two largest and most developed cities in China, located in North and South China, respectively. Beijing and Shanghai possess the best medical universities, the most advanced hospitals, the most substantial medical conditions, and the highest population health literacy of China. According to the population census data in 1990, 2000, and 2010, Shanghai ranked first, whereas Beijing ranked second in China in terms of life expectancy. Furthermore, Beijing has a far lower nonagenarian ratio than Shanghai. Since 1990, North China has consistently showed lower life expectancy and considerably lower longevity ratio than South China (Table 1). Of note, Mainland China has 31 provinces. South and North China each contain 15 provinces. Meanwhile, Tibet is included in neither North nor South China because although Tibet is geographically located in the south, the average elevation is over 4500m, and its temperature, atmospheric pressure, and oxygen content are far lower than those of other provinces.

Table 1 presents the life expectancy and longevity ratio in Shanghai—both ranked first—as well as in Beijing—with longevity ratio merely ranked middle among 31 provinces in China. Why residents of Shanghai far easily live for over 90 years of age compared with those of Beijing?

Methods

Association between age-specific mortality and longevity

To know why residents in North China do not live as long as those in South China, we calculated age-specific mortality per 100,000 people in North and South China. The results are illustrated in Fig. 1. The number of deaths in the population aged 55–89 years was significantly lower in Shanghai than in Beijing. Meanwhile, the number of deaths in the population aged 55–89 years was significantly lower in South China than in North China, whereas the numbers of deaths in the populations aged 0–55 years and 90–100 years were almost the same. In general, a lower mortality rate of the population aged 55–89 years in Shanghai and South China led to a greater proportion of older population. A few years later, some of them will become nonagenarians or even centenarians. Hence, Beijing showed a slightly lower life expectancy and a considerably lower proportion of longevity population than Shanghai.

High medical security in Beijing reduced the mortality rate of younger population, providing an important support for the highest life expectancy. However, the mortality rate of people aged 55–89 years was generally 50–150 times higher than that of people aged under 35 years, indicating that the population aged 55–89 years experienced the highest number of deaths (Fig. 1). If the mortality rate of people aged 55–89 years decreases slightly, many people will live to over 90 years and the longevity ratio will sharply increase in a short term.

Therefore, considering that the mortality rate of people aged 55–89 years in Beijing is higher than that in Shanghai, the proportion of people over 90 years of age in Beijing is considerably lower than that in Shanghai. The same trend applies to North and South China.

Results

Age-standardized rates of four major fatal diseases between North and South China

To study the reason underlying differences in longevity between North and South China, we selected the mortality rate of major fatal diseases, according to the statistical data of leading mortality causes in China⁶. CVD, tumors, and respiratory diseases were the three leading causes of death in both rural and urban populations in China. Of all deaths in rural and urban areas, CVD-related deaths accounted for 45.50% and 43.16%, followed by tumor-related deaths at 22.92% and 26.06% and respiratory disease-related deaths at 12.02% and 11.24%, respectively. Overall, the three diseases accounted for 80.44% and 80.46% of all deaths in rural and urban areas, respectively. Moreover, the contribution of CVD and respiratory diseases to all-cause mortality rate increased with age but that of tumors decreased with age (Table 2).

CVD can be further divided into cerebrovascular and heart diseases. To compare the mortality rates of the four major diseases between North and South China, we collected and mapped the provincial mortality rate data⁷ (Fig. 2). Comparisons between North and South China as well as between Beijing and Shanghai are presented in Table 3.

Discussion

As illustrated in Table 3, except those of cerebrovascular disease and heart disease, the mortality rates of all other reasons in Shanghai and South China were higher than those in Beijing and North China, respectively. Thus, the difference of CVD mortality rates is the fundamental reason for the difference of the longevity level between North and South China.

To evaluate the correlations among the four major diseases and nonagenarian ratio, we generated a Spearman's rank correlation matrix (Table 4). The correlation coefficients between the nonagenarian ratio and CVD were significant and negative, whereas the correlation coefficients between the nonagenarian ratio and illnesses such as cancer and respiratory diseases were not significant.

Based on this matrix, we conducted correlation and principal component analyses to determine the associations of the nonagenarian ratio with the major diseases (Table 5). The order in which factors were interpreted was determined based on the magnitude of their eigenvalues. In Table 5, the eigenvalues of the first factor (F1) are considerably higher than those of F2 and F3, and F1 showed a high positive loading for CVD.

The proportion of nonagenarians in northern provinces was significantly lower than that in southern provinces (Table 1), possibly due to the significant and positive correlation with CVD. Fig. 2 and Table 3 illustrate that among the four major diseases, cancer is randomly distributed in China. Additionally, the mortality rate of respiratory diseases in South China is generally higher than that in North China. Conversely, the mortality rate of CVD in South China is generally lower than that in North China, which is consistent with other studies 9: Nine provinces in North China, namely Heilongjiang, Jilin, Liaoning, Inner Mongolia, Hebei, Beijing, Ningxia, Tibet, and Xinjiang, have a high incidence of stroke, constituting a stroke belt in China. The stroke incidence in the stroke zone was 236.2/100,000, which was significantly higher than that in the areas outside the stroke zone (109.7/100,000). Considering that the mortality rate of CVD is considerably higher than that of respiratory diseases, a lower mortality rate of CVD in South China led to higher life expectancy and longevity ratio.

Based on the 2010 national census data for China, the provincial gravity center evolution map for the proportion of population from over 65 years to over 100 years was drawn (Fig. 3).

Fig. 3 shows that the provincial gravity centers of the proportion of aging population and longevity population move southward as the age increases, and this shift does not reverse. As the age increases, the gravity centers of the proportion of aging population in China move along the same path as that of the gravity centers of the lowest temperature during winter. The speed is gradually accelerating southward, as illustrated in Table 6.

According to CVD reports in China in 2015, 2016, 2017, and 2018¹⁰, some influencing factors for CVD (e.g., temperature, salt consumption, selenium intake, air pollution, overweight, and obesity) may present north–south differences.

High sodium intake is internationally recognized as the main cause of hypertension. In fact, 25.2% of the CVD deaths can be attributed to high-sodium diets, ranking first among all diseases; the disease burden attributable to high-sodium diets in North China is considerably more serious than that in South China; the top 10 provinces with high disease burden due to high-sodium diets were all located in the north¹¹.

Extreme temperatures have a significant impact on mortality in elderly people¹². The associations of high and low temperature with death differ, and more cold-related deaths have been reported than heat-related deaths¹³. Furthermore, the effects of low temperatures may persist for several days¹⁴, whereas those of high temperatures are restricted to the day of the death or to the next day for all CVD cases; the hot-day effect was five times less severe than the cold-day effect¹⁵. In Shenzhen, there was a significant increase in CVD mortality rate over low-temperature days compared with that over high-temperature days¹⁶. North China is considerably colder than South China during winter, possibly leading to higher CVD mortality rate. However, in summer, North China also faces heat waves.

In medical cases and clinical reports of 133,957 people, selenium intake was negatively correlated with CVD mortality risk in males and females¹⁷, and the distribution of selenium in the soil of China gradually increases from north to south¹⁸. Furthermore, air pollution is becoming a threat to public health. In several studies, PM_{2.5}, SO₂, and NO₂ were positively correlated with hypertension and CVD, and PM₁₀ and PM_{2.5} gradually decrease from north to south in China. The government provides free or heavily subsidized coal for indoor heating during the winter to cities north of the Huai River but not to those in the south; excess coal burning pollutes the air in the north; furthermore, the short lifespans are almost entirely caused by elevated rates of CVD mortality^{19,20}.

In addition, obesity and overweight are two of the most common causes of CVD. These are highly prevalent in north and northeastern areas of China²¹. A report on risk factor surveillance of chronic disease in China also showed that obesity and overweight are more prevalent in North China than in South China, and top one-third provinces with high obesity and overweight rate are all located in the north²².

Conclusion

1. Lower mortality rates of individuals aged 55–89 years in South China lead to higher longevity
2. Mortality rate of CVD accounts for over 50% of all-cause mortalities in people aged over 80 years, except those of cerebrovascular disease and heart disease, the mortality rates of all other reasons in South China were higher than those in North China
3. The mortality rate of CVD and its risk factors gradually decreases from north to south.
4. Provincial gravity centers of the proportion of longevity population move southward, and this shift is accelerated with increasing age.

Abbreviations

CVD: Cerebrovascular disease and heart disease.

Declarations

Ethics approval and consent to participate: Not required

Consent for publication: consent for publication was obtained from all participants. **Availability of data and materials:** the Fifth and Sixth National population census; 2017 Year book of health and family planning in the People's Republic of China; Report on cardiovascular diseases in China 2017, China Death Cause Surveillance Data Set 2013; Report on Chinese Residents' Chronic Disease and Nutrition 2015.

Competing interests: None declared

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Authors' contributions: Yi Huang designed the experiment, Yi Huang wrote the paper, Mengqi Wang, Shuangping Zhang and Yanxin Song collected the data. All authors have read and approved the manuscript.

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Tables

Table 1. Life span indicators between Beijing and Shanghai and between North and South China

Year	Life expectancy and ranking				Longevity ratio (90+/0+)	
	1990	2000	2010	2018	2000	2010
Beijing	72.9	76.1	80.2	82.2	0.43‰ ¹³	1.27‰ ¹⁶
Shanghai	74.9	78.1	80.3	83.6	0.79‰ ¹	2.75‰ ¹
North China	68.1	71.4	75.0	-	0.30‰	1.03‰
South China	68.7	71.6	75.2	-	0.43‰	1.67‰
China	68.6	71.4	74.8	77.0	0.39‰	1.49‰

Columns on the right of life expectancy and longevity ratio is the rank of Beijing and Shanghai

Table 2. Change of mortality rate (per 100 000) of main diseases and proportion in all-cause mortality with age

Age (years)	CVD		tumors		Respiratory diseases		Other diseases		Non-disease	
85+	10441.75	55.69%	2078.58	11.09%	3226.86	17.21%	2365.68	12.62%	637.62	3.40%
80-84	4061.87	52.53%	1486.69	19.23%	1160.37	15.01%	807.81	10.45%	215.73	2.79%
75-79	1755.33	48.34%	926.2	25.51%	470.45	12.96%	371.13	10.22%	107.83	2.97%
70-74	982.77	43.89%	711.27	31.76%	238.53	10.65%	227.74	10.17%	79.06	3.53%
65-69	613.77	39.18%	597.36	38.14%	121.03	7.73%	160.39	10.24%	73.83	4.71%

Table 3. Age-standardized mortality rates (per 100,000 people) with the leading causes in 2013

	Cerebrovascular disease	Heart disease	Respiratory diseases	Lung cancer	Liver cancer	Stomach cancer	Colon and rectum cancer	Total of four major cancers	Total of four major diseases	Mortality rate	Mortality rate without CVD
Males in Beijing	144.5	154.7	56.6	51.5	20.3	15.1	15.2	102.1	457.8	438.3	139.1
Males in Shanghai	97.8	65.2	74.5	52.2	21.1	25.4	18.9	117.6	355.1	415.9	252.9
Females in Beijing	91.7	108.6	37.1	23.4	7	5.5	10.2	46.1	283.5	356.1	155.8
Females in Shanghai	79.8	49.7	35.7	17.9	8.2	11.1	13.9	51.1	216.3	331.7	202.2
Males in the north	199.84	196.6	99.18	52.6	29.2	37.2	11.35	130.4	625.9	632.4	236.0
Males in the south	170.88	129.8 ⁵	143.3 ⁵	58.8 ³	39.7 ³	30.1 ¹	14.14	142.8 ¹	586.8 ⁹	618.4	317.7
Females in the north	136.15	144.0 ³	72.21	23.1 ⁹	12.2 ²	14.5 ⁶	7.94	57.91	410.3	509.5	229.4
Females in the south	116.28	92.19	90.68	19.0 ⁵	12.7 ⁹	12.3 ⁷	9.39	53.6	352.7 ⁵	458.6	250.1

Mortality rate is the age-standardized mortality rate of all causes according to the sixth population census in 2010

Table 4. Spearman's rank correlation matrix for major diseases and nonagenarian ratio

	Cerebrovascular disease	Heart disease	Cancer	Respiratory diseases
Male	-0.423*	-0.467**	-0.138	0.319
Female	-0.515**	-0.679**	-0.217	-0.102

* and ** denote significant correlations at $p < 0.05$ and $p < 0.01$, respectively

Table 5. Results of principal component analysis

Component	Male			Female	
	1	2	3	1	2
Total	2.046	1.143	1.113	2.325	1.064
Initial eigenvalues					
% of variance	40.91%	22.86%	22.26%	46.50%	21.27%
Cerebrovascular disease	0.781	0.166	0.435	0.839	-0.030
Heart disease	0.865	0.288	-0.05	0.894	-0.317
Cancer	-0.138	-0.759	0.588	0.207	0.931
Respiratory diseases	-0.28	0.51	0.759	0.276	0.307
Nonagenarian ratio	-0.769	0.443	0.004	-0.839	-0.036

Table 6. Latitude of the gravity center and latitude moving southward across different age groups

Age (years)	65	70	75	80	85	90	95	100
Latitude °N	33.70	33.55	33.31	33.03	32.73	32.28	31.26	29.62
Latitude moving southward °N	0.15	0.24	0.28	0.30	0.45	1.02	1.64	

Figures

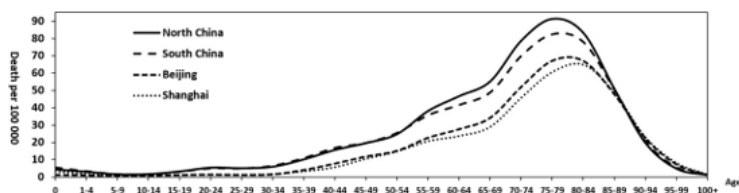


Figure 1

Difference in age-specific mortality between Beijing and Shanghai under the same age structure

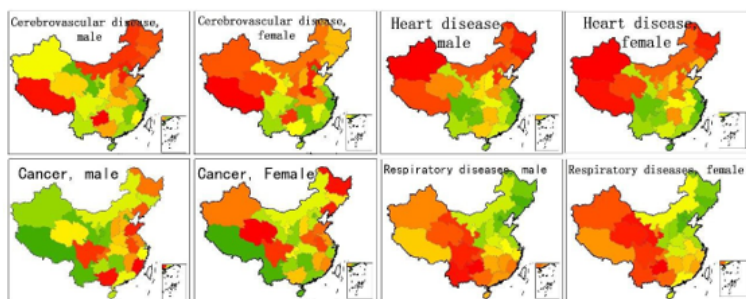


Figure 2

Distribution of age-standardized mortality rates of four major fatal diseases. Warmer colors indicate higher mortality rate Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal

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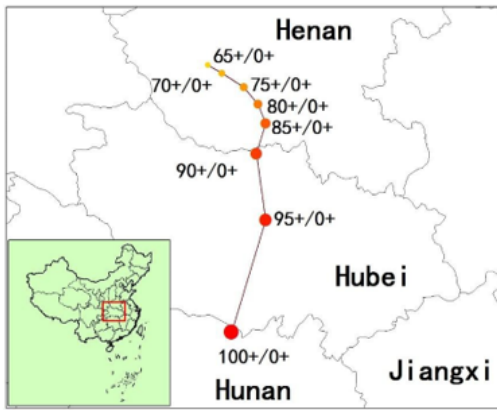


Figure 3
Evolution map of the gravity centers of longevity indicators in China Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.