Original Article

Impact of Cerebrovascular Disease Mortality on Life Expectancy in China*

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Abstract

Objective To evaluate the impact of cerebrovascular disease mortality on life expectancy (LE) in China in 2010 compared with 2005, and to identify the high-risk population (age, sex, and region) where cerebrovascular disease mortality has had a major impact on LE.

Methods LE and cause-eliminated LE were calculated by using standard life tables which used adjusted mortality data from the Death Surveillance Data Sets in 2005 and 2010 from the National Disease Surveillance System. Decomposition was used to quantitate the impact of cerebrovascular disease in different age groups.

Results LE in China was 73.24 years in 2010, which was higher in women and urban residents compared with men and rural residents. The loss of LE caused by cerebrovascular disease mortality was 2.26 years, which was higher in men and rural residents compared with women and urban residents. More than 30% of the loss of LE were attributed to premature death from cerebrovascular disease in people aged <65 years. Compared with 2005, LE in 2010 increased by 0.92 years. The reduction of cerebrovascular disease mortality in urban residents contributed 0.45 years to the increase of LE, but the increase of cerebrovascular disease mortality caused a 0.12-year loss of LE in rural residents.

Conclusion Cerebrovascular disease mortality had a major impact on LE in China, with a significant difference between urban and rural residents. LE is likely to be further increased by reducing cerebrovascular disease mortality, and special attention should be paid to reducing premature deaths in people aged <65 years.

Key words: Cerebrovascular disease; Life expectancy; Loss of Life

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INTRODUCTION

Life expectancy (LE) is an important indicator to evaluate the health of population and social development levels[1-2]. The social and economic development in China has greatly improved standard of living and people's health, and LE increased from 43.46 to 73.27 years between 1960 and 2010[3]. There has been a significant decline in infant mortality and mortality due to infectious diseases and a rapid increase in chronic disease prevalence in China.

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According to the data from National Disease Surveillance System, chronic disease accounted for 85.31% of deaths in 2009[4]. Cerebrovascular disease is one of the major chronic diseases. The data from China Health Statistics Yearbook shows that cerebrovascular disease ranked third among common causes of death for urban residents and first for rural residents in 2010[5]. Deaths from cerebrovascular disease seriously threaten public health. Evaluating the impact of cerebrovascular disease mortality on LE can yield more information about main health problems, and provide valuable data for the formulation of public health policies. However, there is little information about the impact of cerebrovascular disease mortality on LE in recent years. This study was designed to quantitate the impact of cerebrovascular disease deaths on LE at national level in China.

MATERIALS AND METHODS

Data Source

The data was collected from the Cause of Death Surveillance Data Sets and National Disease Surveillance System, which were published by the Chronic Disease Center, Chinese Center for Disease Control and Prevention (China CDC). Based on the principle that the characteristics of the population under surveillance must be similar to those of the general population in different geographic areas, multistage cluster probability sampling was designed for the population sample under the surveillance system[6]. Nowadays, the Surveillance System covers 31 provinces (autonomous regions and municipalities), including 161 disease surveillance sites (64 in urban area and 97 in rural area), covering >70 million people (6% of population in China), and has a good representation of the country. Before the publication of the data, China CDC would verify the data from each surveillance site, two surveillance sites in 2005 and four in 2010 were excluded due to the low quality of the data reported.

Registration of Deaths and Major Causes of Death Coding

At each surveillance site, all of the deaths had been registered. If people died in hospital, the doctor would diagnose the cause of death and fill in 'medical certificate of death'. If people died at home or in other places, community physicians would regularly report the information to township hospitals or community health service centers. According to the medical history or medical diagnoses which were provided by the deceased's family or other insiders, the doctor in the township hospitals or community health service centers would diagnose the cause of death, and then fill in the 'medical certificate of death'.

Causes of death were coded according to the International Classification of Diseases, the 10th edition (ICD10). Major causes of death included cerebrovascular disease (ICD-10 codes I60-I69), cardiovascular diseases (I00-I09, I10-I13, I20-I28, I30-I37, I38, I40, I42, I44-I51, I60-I99), malignant tumors (C00-C97), injury and poisoning (codes V01-Y89), respiratory diseases (J00-J99), and perinatal diseases (P00-P96).

Under-reporting Correction of Death Data

Under-reporting is a common problem in the data reported through National Disease Surveillance System. Results about under-reporting of mortality surveillance were investigated by China CDC[7] and the under-reporting of the infant death rate published by the National Maternal and Child health Monitoring System[8] were used to adjust the crude mortality in each age group. The formula was: corrected age-specific mortality = crude age-specific mortality/(1-age-specific under-reporting rate)[7].

Calculation of LE

LE and cause-eliminated LE were calculated with the standard life table techniques (Chiang's method)[9]. Life table techniques can not evaluate the impact of death on LE changes between different populations, and can not break down the life loss to each age group, therefore, we used the method of age decomposition of LE put forward by Arriaga to calculate the impact of cerebrovascular disease deaths on LE changes from 2005 to 2010, and broke down the Loss of LE by cerebrovascular disease deaths to each age group in 2010. The formulas below describe the method of age decomposition of LE for a specific age group between two populations or two time points[10-11]. ${}_nTE_x$ denotes the contribution of all-cause mortality changes to LE for the age interval (x, x+n) from 2005 to 2010 or the Loss of LE due to cerebrovascular disease deaths in 2010 for the age interval (x, x+n). '*l*' and '*T*' were the general terms in the life table (*l*, number of survivors and *T*, total number of surviving person-years), '1' and '2' represent two populations or two time points. In equation form,

$$ {}_nTE_x = \frac{l_x^1}{l_0^1} \cdot \left(\frac{T_x^2 - T_{x+n}^2}{l_x^2} - \frac{T_x^1 - T_{x+n}^1}{l_x^1} \right) + $$

$$ \frac{T_{x+n}^1}{l_0^1} \cdot \left(\frac{l_x^1 \cdot l_{x+n}^2}{l_{x+n}^1 \cdot l_x^2} - 1 \right) + \frac{T_{x+n}^2}{l_0^1} $$

$$ \cdot \left(\frac{l_x^1}{l_x^2} - \frac{l_{x+n}^1}{l_{x+n}^2} \right) - \frac{T_{x+n}^1}{l_0^1} \cdot \left(\frac{l_x^1 \cdot l_{x+n}^2}{l_{x+n}^1 \cdot l_x^2} - 1 \right) $$

For the last age group, the formula is,

$$ {}_nTE_x = \frac{l_x^1}{l_0^1} \cdot \left(\frac{T_x^2}{l_x^2} - \frac{T_x^1}{l_x^1} \right). $$

The effect of a specific cause in the interval (x, x+n), ${}_nTE_{x_i}$ is equal to ${}_nTE_x$ times a factor (${}_nk_x$), which is given by

$$ {}_nTE_{x_i} = {}_nTE_x \times {}_nk_x \ , $$

$$ {}_nk_x = \left[\frac{{}_nR_x^2 \cdot {}_nm_x^2 - {}_nR_x^1 \cdot {}_nm_x^1}{{}_nm_x^2 - {}_nm_x^1} \right] $$

${}_nR_x$ denotes the ratio of the cause i among all causes of death in an age group (x, x+n), ${}_nm_x$ is the general term in the life table.

All analyses were performed by using SPSS software (version 13.0; SPSS Inc., Chicago, IL, USA).

RESULTS

Cerebrovascular Disease Mortality in 2010 and 2005

The National Disease Surveillance System covered >70 million people (6% of total population in China) in 2005 and 2010, and 36% of people lived in urban areas. The number of men and women was nearly equal. Table 1 shows the age-standardized mortality of cerebrovascular disease in different populations. In 2010, the age-standardized mortality of cerebrovascular disease in China was 178.98 per 100 000, and it was higher in rural area than in urban area (196.07 per 100 000 *vs.* 132.23 per 100 000), and men had a higher mortality rate than women (192.52 per 100 000 *vs.* 163.86 per 100 000). Compared with 2005, age-standardized mortality of cerebrovascular disease increased in both men and women, but declined in urban area and increased in rural area.

LE in China in 2010 and 2005

Table 2 shows that LE at birth in China was 73.24 years in 2010: 71.04 years in men and 75.82 years in women; 76.59 years in urban residents and 72.08 years in rural residents. Compared with 2005, LE increased by 0.92 years during the 5 years to 2010. The gender specific difference in LE declined from 4.87 to 4.78 years, and the gap between urban residents and rural residents increased from 4.25 to 4.51 years.

Contribution of Cerebrovascular Disease Deaths to the Loss of LE in 2010 (age, sex, region)

In 2010, the top five major causes of death in China that resulted in an overall 10.59-year reduction in LE were: cardiovascular disease (4.79 years), malignant tumors (2.66 years), injury and poisoning (1.53 years), respiratory diseases (1.15 years) and perinatal diseases (0.46 years). As for the 4.79-year loss of LE caused by cardiovascular disease, 2.26 years (47%) were from cerebrovascular disease, 1.21 years from ischemic heart disease, and 1.32 years from other cardiovascular diseases. The loss of years of LE caused by cerebrovascular disease deaths in different populations is shown in Table 3. Totally 31.9% of Loss of LE were from premature deaths caused by cerebrovascular disease in population under age 65 years. Men had a greater loss of LE than women (2.24 years *vs.* 2.19 years), and rural residents had a greater loss than urban residents (2.41 years *vs.* 1.79 years).

Table 1. Cerebrovascular Disease Mortality (Per 100 000 Population) in 2005 and 2010

Items	Year	Total	Men	Women	Sex Difference (%)
Total	2005	163.80	175.35	151.44	15.79
	2010	178.98	192.52	163.86	17.49
	Increase (%)	9.27	9.79	8.20	
Urban	2005	142.51	149.73	133.45	12.20
	2010	132.23	140.53	120.76	16.37
	Increase (%)	-7.21	-6.14	-9.51	
Rural	2005	170.25	183.02	156.95	16.61
	2010	196.07	211.26	179.84	17.47
	Increase (%)	15.17	15.43	14.58	

Contribution of change of Cerebrovascular Disease mortality to Increase in LE from 2005 to 2010 (age, sex, region)

The contribution of the change of cerebrovascular disease mortality in different populations to the increase in LE from 2005 to 2010 is shown in Table 4. The change in cerebrovascular disease mortality increased LE in China by 0.04 years, accounting for 4% (0.04 *vs.* 0.92) of the total gains in LE during the 5 years. In detail, the main contribution came from age group 40-80 years, which resulted in an overall increase of 0.18 years LE. Conversely, in age groups 15-40 and >80 years there was a 0.15-year loss of LE. The contribution was slightly higher for men than women, and there was a significant difference between rural area and urban area. In urban areas, 45% (0.45 *vs.* 0.99) of the increased LE in the past 5 years came from the reduction in cerebrovascular disease mortality, and 99% of the contribution came from age group 40-80 years. However, in rural residents, the increase in cerebrovascular disease mortality led to a 0.12 year loss of LE. This reduced the total gains in LE by ~16% (-0.12 *vs.* 0.73) in the past 5 years. Apart from people aged 40-64 years, in whom there was a positive effect on LE, cerebrovascular disease mortality had a negative effect on LE in almost all the other rural residents.

DISCUSSION

The main findings in present study indicated that cerebrovascular disease was the second leading cause of death that affected LE in China, and men had a greater loss of LE caused by cerebrovascular disease than women. Similarly, rural residents had

Table 2. LE According to Sex and Area in 2005 and 2010

Items	Year	Total	Men	Women	Gender Differences
Total	2005	72.31	70.04	74.91	4.87
	2010	73.24	71.04	75.82	4.78
	increase	0.93	1.00	0.91	-0.09
Urban	2005	75.60	73.67	77.84	4.17
	2010	76.59	74.76	78.72	3.96
	increase	0.99	1.09	0.88	-0.21
Rural	2005	71.35	69.01	74.05	5.04
	2010	72.08	69.79	74.79	5.00
	increase	0.73	0.78	0.74	-0.04

Table 3. Loss of LE Caused by Cerebrovascular Disease in 2010

Age group (years)	Total		Men		Women		Urban		Rural	
	Loss years	Proportion in total (%)	Loss years	Proportion in total (%)	Loss years	Proportion in total (%)	Loss years	Proportion in total (%)	Loss years	Proportion in total (%)
0-5	0.0051	0.23	0.0065	0.29	0.0030	0.14	0.0025	0.14	0.0057	0.24
5-15	0.0024	0.11	0.0032	0.14	0.0016	0.07	0.0018	0.10	0.0027	0.11
15-40	0.0588	2.60	0.0781	3.48	0.0339	1.55	0.0440	2.46	0.0636	2.64
40-65	0.6552	29.02	0.7443	33.14	0.5253	23.95	0.4494	25.12	0.7314	30.41
65-80	1.1031	48.85	1.0930	48.66	1.0669	48.65	0.8124	45.42	1.1964	49.74
80-	0.4334	19.19	0.3212	14.30	0.5624	25.64	0.4786	26.76	0.4055	16.86
Total	2.2580	100.00	2.2462	100.00	2.1932	100.00	1.7887	100.00	2.4052	100.00

Table 4. Contribution of All-cause and Cerebrovascular Disease Mortality to Gains in LE from 2005 to 2010

Age		Total		Men		Women	
		${}_nTE_x$	${}_nTE_{xi}$	${}_nTE_x$	${}_nTE_{xi}$	${}_nTE_x$	${}_nTE_{xi}$
Total	0-5	0.4216	0.0018	0.4105	-0.0015	0.4091	0.0064
	5-15	0.0147	0.0001	0.0206	0.0004	0.0118	-0.0001
	15-40	0.1005	-0.0051	0.1016	-0.0116	0.1283	0.0054
	40-65	0.5342	0.0982	0.4943	0.0782	0.6031	0.1256
	65-80	0.4027	0.0864	0.3517	0.0752	0.4876	0.1049
	80-	-0.5349	-0.1422	-0.3819	-0.0929	-0.7348	-0.2049
	Total	0.9187	0.0392	0.9969	0.0478	0.9052	0.0373
Urban	0-5	0.2688	0.0028	0.2806	0.0043	0.1850	0.0006
	5-15	0.0517	-0.0002	0.0572	0.0001	0.0455	-0.0005
	15-40	0.0212	-0.0013	0.0250	-0.0037	0.0317	0.0032
	40-65	0.4560	0.1362	0.4255	0.1457	0.5220	0.1295
	65-80	0.7999	0.3084	0.7196	0.2965	0.8913	0.3203
	80-	-0.6047	0.0036	-0.4182	0.0115	-0.7898	0.0088
	Total	0.9929	0.4496	1.0899	0.4544	0.8858	0.4619
Rural	0-5	0.4460	0.0013	0.4258	-0.0040	0.4574	0.0086
	5-15	-0.0016	0.0000	0.0043	-0.0002	-0.0029	0.0000
	15-40	0.1056	-0.0061	0.0994	-0.0126	0.1464	0.0056
	40-65	0.4993	0.0737	0.4429	0.0459	0.5836	0.1119
	65-80	0.2155	-0.0174	0.1868	-0.0223	0.2877	0.0000
	80-	-0.5392	-0.1699	-0.3803	-0.1122	-0.7319	-0.2738
	Total	0.7256	-0.1183	0.7788	-0.1053	0.7404	-0.1477

Note. ${}_nTE_x$, contribution by all-cause mortality; ${}_nTE_{xi}$, contribution by cerebrovascular disease mortality.

greater loss of LE caused by cerebrovascular disease than urban residents. The major loss of LE caused by cerebrovascular disease was contributed by people aged >65 years, but, the premature death in people aged <65 years also played a major role. Compared with 2005, the change in cerebrovascular disease mortality had little positive impact on LE in China in men and women, but there was a large difference between urban residents and rural residents.

LE is an important health and economic indicator calculated by the age-specific death rates, and is a more intuitive index compared with mortality rate[1-2]. Meanwhile, when calculating LE, it may give younger people, especially infants, greater weight; in other words, it will be impacted more easily by the deaths of younger people[9]. However, with the change of spectrum of disease, the increase in the number of deaths from chronic diseases (which occur mainly in adults) has resulted in cerebrovascular disease and malignant tumors becoming the leading causes of death that affect LE in China. The loss of LE is stranded for the degree of impact on LE by a certain cause of deaths. However, as far as we know, no in-depth study on the impact of cerebrovascular disease mortality on LE in China has been conducted in recent years. Our study analyzed the impact of cerebrovascular disease deaths on LE in China and its distribution across different sexes, regions, and age groups, as well as its contribution in recent years to the increase in LE.

We found that LE was affected more slightly by cerebrovascular disease deaths in men than in women, and men aged <65 years were more greatly affected by premature death caused by cerebrovascular disease than women. This may be explained by that men are exposed to relatively higher risks than women. Many studies have shown that the prevalence of cerebrovascular disease risk

factors such as metabolic syndrome[12], hypertension[13-14], diabetes[15], obesity[12], smoking[16], and alcohol consumption[17] is higher in men than women. Therefore, more efforts should be made to decrease the incidence of cerebrovascular disease risk factors in men, especially in the younger age groups.

The impact of cerebrovascular disease deaths on LE differed significantly between urban residents and rural residents. First, the loss of LE caused by cerebrovascular disease was greater in rural residents than in urban residents in 2010 (2.41 *vs.* 1.79 years). Second, during 2005-2010, the reduction in cerebrovascular disease mortality made a large contribution to the increase of LE in urban residents. Forty-five percent of the increase in LE was due to the reduction in cerebrovascular disease mortality. However, cerebrovascular disease mortality increased in rural residents and led to a 0.12 year loss of LE. According to the epidemiological transition pattern, China's health challenge has shifted from the second stage of receding pandemics to the third stage of degenerative and human-made diseases[18]. In our study, the urban and rural populations were at different stages of transitions, with rural areas lagging behind urban areas. Data from the Health and Nutrition Survey in 2002 showed that the Chinese population had a relatively high exposure to risk factors, and the prevalence of cardiovascular risk factors, such as hypertension, diabetes, obesity, smoking, alcohol consumption, and high-salt diet, was higher in rural than urban areas[4]. The lower awareness rate of these risk factors and less related treatment and control were observed in rural residents than in urban residents obviously[4,14]. The China's rural population is large, and its health level has a major impact on the total LE in China. It is time to pay more attention to cerebrovascular disease mortality in rural areas.

In 2010, the loss of LE caused by cerebrovascular disease was 2.26 years, and >30% of that came from the cerebrovascular disease caused premature death under 65 years of age. From 2005 to 2010, in urban areas, cerebrovascular disease mortality had a certain reduction in people aged >40 years, and made a major contribution to the increase in LE, but cerebrovascular disease deaths had no reduction for <40 years old people who did not contribute to the increase of LE in urban areas. In rural residents, the increase in cerebrovascular disease mortality in age group 65-80 years, especially in those aged >80 years, had a negative effect on LE. In addition to the negative effect on LE in young age group (<40 years old), there was nearly no positive contribution in other age groups. Our results suggest that we should not only try to reduce cerebrovascular disease mortality in older people, but also pay more attention to death from cerebrovascular disease in those aged <65 years.

Our study has some limitations which need to be addressed. First, to make the crude mortality data from the surveillance system more realistic, we made an adjustment to take account of possible under-reporting, but the adjusted data still differed from the real situation. Second, we can only calculate the LE but not the healthy LE; however, people may focus not only on how long they can live but also the number of years of good health. Third, LE is only concerned with death. Improvement in medical treatment in China has resulted in an increase in non-fatal outcomes of diseases. Therefore, if we want to evaluate disease burden, we can estimate indexes such as potential years of life lost, disability-adjusted life years, and disability-adjusted LE.

In conclusion, cerebrovascular disease mortality has a major impact on LE in China. There is a significant difference in this impact between urban and rural residents. LE is likely to be further increased by reducing deaths caused by cerebrovascular disease, and special attention should be paid to reducing premature death caused by cerebrovascular disease in people aged <65 years.

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REFERENCES

1. Wilkinson RG. Income distribution and life expectancy. BMJ, 1992; 304, 165-8.
2. DEATON A. Health, Inequality, and Economic Development. Journal of Economic Literature, 2003; XLI, 113-58.
3. The World Bank. Life expectancy at birth[DB/OL]. http://data.worldbank.org/indicator/SP.DYN.LE00.IN/countries/all?display=default, 2013.
4. Wang N. National Disease Surveillance System: The Cause of Death Surveillance Data Sets in 2010. Beijing: Military Medical Sciences, 2012; 20-130.
5. Ministry of Health of the People's Republic of China. China

Health Statistics Yearbook data. Beijing: China Union Medical University Press, 2011; 290-329.
6. Yang G, Hu J, Rao KQ, et al. Mortality registration and surveillance in China: History, current situation and challenges. Popul Health Metr, 2005; 3, 3.
7, Wang L, Ma LM, and Zhou MG. Characteristics of under-reporting of Mortality Surveillance from 2006 to 2008 in China. Chinese Journal of Preventive Medicine, 2011; 45, 0-1. (In Chinese)
8. Institute of Population and Labor Economics CAoS. China Demographic Yearbook of 2011. Beijing: China Population Yearbook Press, 454.
9. Chiang C. The Life Table and Its Applications. Malabar, Florida: Robert E Krieger Publ Co; 1984.
10. Arriaga EE. Measuring and explaining the change in life expectancies. Demography, 1984; 21, 83-96.
11. Arriaga EE. Changing trends in mortality decline during the last decades. In：Ruzicka LT, Wunsch GJ, Kane P, eds. Differential Mortality: Methodological Issues and Biosocial Factors. Oxford, England：Clarendon Press, 1989; 105-29.
12. Gu DF, Reynolds K, Wu XG, et al. Prevalence of the metabolic syndrome and overweight among adults in China. Lancet, 2005; 365, 1398-405.
13. Gu DF, Reynolds K, Wu XG, et al. Prevalence, awareness, treatment, and control of hypertension in china. Hypertension, 2002; 40, 920-7.
14. Wu Y, Huxley R, Li L, et al. Prevalence, awareness, treatment, and control of hypertension in China: data from the China National Nutrition and Health Survey 2002. Circulation, 2008; 118, 2679-86.
15. Yang WY, Lu JI, Weng JP, et al. Prevalence of diabetes among men and women in China. N Engl J Med, 2010; 362, 1090-1.
16. Gu DF, Wu XG, Reynolds K, et al. Cigarette smoking and exposure to environmental tobacco smoke in China: the international collaborative study of cardiovascular disease in Asia. Am J Public Health, 2004; 94, 1972-6.
17. Wang LD. China National Nutrition and Health Survey report in 2002: the consolidated report. Beijing: People's Medical Publishing House, 2005.
18. Gaziano TA, Bitton A, Anand S, et al. Growing epidemic of coronary heart disease in low- and middle-income countries. CurrProblCardiol, 2010; 35, 72-1.