Original Article

Impact of Cardiovascular Disease Deaths on Life Expectancy in Chinese Population*

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Abstract

Objective We aimed to analyze the impact of cardiovascular disease (CVD) deaths on life expectancy (LE) in Chinese population and estimate the percentage reduction in CVD mortality needed to increase LE by 1 year from the current level, a national target of health improvement.

Methods We used life tables, cause-elimination life tables, and age decomposition of LE with corrected mortality data from the National Disease Surveillance System in 2010.

Results LE at birth of Chinese people was 73.24 years in 2010. Women had a longer LE than men, and urban population had a longer LE than rural population. CVD deaths resulted in a 4.79-year LE loss and premature deaths in people aged 25 to 64 years were responsible for a substantial part of LE loss from CVD. Death from ischemic heart disease and cerebrovascular diseases accounted for 69.2% of LE loss from CVD deaths and death from cerebrovascular diseases was the largest contributor. In rural men, 51.1% LE loss from CVD deaths was caused by cerebrovascular diseases. If there were no changes in mortality rates for all other diseases, a 27.4% reduction in CVD mortality would increase LE by 1 year in Chinese population.

Conclusion There is a considerable impact of CVD deaths on LE. A 1-year LE increase in the future requires at least a 27.4% reduction in CVD mortality from the current level. Targeting the rural population and tackling cerebrovascular diseases are important for reaching the national goal of health improvement.

Key words: Life expectancy; Cardiovascular disease; Age decomposition of life expectancy

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INTRODUCTION

Life expectancy (LE) is an important measure for the impact of overall mortality on life span, and reflects disease burden in a population[1-2]. China's 12th Five-Year Plan has set up a goal for population health to increase LE at birth by 1 year in Chinese population from 2011 to 2015. For many decades, the increased LE at birth in China was mainly due to the reduction in infant

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mortality[3]. With rapid economic development and improvement in living conditions and health care, the infant mortality rate in China declined to 13.1 per 1 000 live births in 2010[4], similar to levels of developed countries. However, even if infant mortality can be reduced further, it cannot extend the life span of most of the population. In China, cardiovascular diseases (CVDs) are the leading cause of death and a major health problem. According to the Report on Cardiovascular Diseases in China (2010)[5], approximately 3 million Chinese people die from CVD every year, accounting for 40% of all causes of death. To further increase LE during the next few years, it is important to assess the impact of CVD death on LE and to identify risk populations and major disease in order to conduct targeted intervention and effective prevention and control. Previous studies on the impact of CVD on LE were based on the data of one province or one small city[6-8], and a few studies analyzed the impact of major causes of death on LE by using nationwide data. Therefore, the aims of this study were to assess the impact of CVD deaths on LE of Chinese population in 2010, and to identify the risk population and specific CVD, which are important for increasing LE and estimating the percentage reduction in CVD mortality needed to increase LE by 1 year from the current level.

MATERIALS AND METHODS

Data Source

The data were collected from National Disease Surveillance System in 2010, which provides death data across age, sex, and geographic entities. The Surveillance System is set up in 31 provinces (autonomous regions and municipalities) with 161 disease surveillance sites (64 in urban area and 97 in rural area) and covering more than 75 million people (accounting for approximately 6% of the total population). All death cases were reported through a registration reporting information system and were verified by the Chronic Disease Center, Chinese Center for Disease Control and Prevention (China CDC). China CDC compared and evaluated the data quality of each surveillance site. After data verifying, four surveillance sites were excluded because of poor data quality and 157 surveillance sites were retained.

Coding of Death

The diseases for analysis were defined by using codes from the International Classification of Diseases, 10th edition (ICD-10). The CVD codes include ICD I00-I09, I10-I13, I20-I28, I30-I37, I38, I40, I42, I44-I51, and I60-I99. The ICD codes for ischemic heart disease are I20-I25 and the codes for cerebrovascular diseases are ICD I60-I69.

Analyses

Correction of Death Data The data from National Disease Surveillance System were corrected by considering the effect of the under-reporting of deaths. We used the latest data from investigations of under-reporting of death in 2006-2008 in each age, sex, groups, and regions provided by the national mortality surveillance system[9] and the under-reporting rate of infant death in 2010 provided by the National Maternal and Child health surveillance system. The crude mortality in each age group was corrected accordingly. Corrected age specific mortality = crude age specific mortality / (1 – age specific under-reporting rate).

Calculation of CVD Mortality Rates The CVD mortality rate was calculated by using the number of CVD deaths and the total population covered by the surveillance system in 2010. Area- and sex-specific mortality rates for CVD were calculated and standardized by using the direct method and data of the sixth nationwide census.

Calculation of LE Life tables for men and women by urban and rural areas were calculated with Chiang's method[10]. Cause-eliminated LE was estimated by using cause-elimination life tables[11]. The difference between LE and cause-eliminated LE was the year of LE loss.

We used the method of age decomposition of LE proposed by Arriaga, which broke down the change in LE (i.e., the total effect, ${}_nTE_x$) into three parts: direct effects (${}_nDE_x$), indirect effects (${}_nIE_x$), and interaction effects (${}_nI_x$)[12]. In this study, the total effect was the LE loss due to CVD deaths. We divided the population into 0-4, 5-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, and older than 85 years age groups to analyze the contribution of CVD deaths in each age group to LE loss. We calculated the following equations[12],

$$ {}_nTE_x = {}_nDE_x + {}_nIE_x + {}_nI_x $$

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

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

$$ {}_nI_x = \frac{T^2_{x+n}}{l^1_a} \cdot \left(\frac{l^1_x}{l^2_x} - \frac{l^1_{x+n}}{l^2_{x+n}} \right) - {}_nIE_x $$

where ($_nDE_x$) represents the direct effect of eliminating CVD deaths from each age group on LE. *T* and *l* are both life-table terms, *T* represents the total number of survival person-years, and *l* represents the number of survivors. Superscript '1' and '2' represent the two assumed populations, the population in the surveillance system, and the population, except people who died from CVD in the surveillance system. Subscript '$_{x, x+n}$' represents age groups. *'a'* is the initial age at which the LE is calculated (if LE at birth, a=0). $_nIE_x$ denotes that when eliminating CVD deaths within (and only within) a specific age group, this will produce an increase in the number of survivors at the end of the age interval. These survivors will also make a contribution to a change in LE. $_nI_x$ denotes the interaction contribution.

For the open-ended age group (the last age group), there is only a direct effect. The formula is[12],

$$ DE_{x+} = \frac{l^1_x}{l^1_a} \cdot \left(\frac{T^2_x}{l^2_x} - \frac{T^1_x}{l^1_x} \right) $$

Analysis of Changes in CVD Mortality and LE at Birth LE was calculated when CVD mortality decreased by 5%, 10%, 15%, 20%, 25%, and 30% on the basis of CVD mortality level in 2010. A function of the relationship of the percentage reduction in CVD mortality and LE was established. Finally, the percentage by which CVD mortality needed to be reduced was evaluated based on if LE was increased to the target level according to the function.

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

RESULTS

Cardiovascular Disease Mortality Rates

In 2010, the age-standardized CVD mortality rate of Chinese population was 331.8 per 100 000 (Table 1 shows age specific CVD mortality). The CVD mortality rate was higher in rural area than that in urban area (age-standardized rate, 233.9 per 100 000 in urban population and 367.6 per 100 000 in rural population). Men had a higher CVD mortality rate than women (age-standardized rate, 373.1 per 100 000 in men and 313.3 per 100 000 in women).

Table 1. Age-specific Rates of Death From CVD (Per 100 000 Population), 2010

Age group (years)	Total	Men	Women	Urban	Rural
0-	10.61	12.19	8.31	7.12	15.25
1-	1.59	1.65	1.99	1.23	1.69
5-	0.81	1.00	0.59	0.73	0.84
10-	1.24	1.28	1.20	1.02	1.32
15-	3.83	4.45	3.07	3.44	3.94
20-	5.99	7.67	4.02	5.07	6.22
25-	9.78	12.44	6.71	7.25	10.82
30-	18.07	24.77	10.62	12.01	20.36
35-	30.17	41.53	17.44	22.89	32.81
40-	60.65	82.39	36.21	49.13	64.68
45-	102.09	134.68	66.00	80.78	111.42
50-	160.48	204.99	110.70	113.07	183.14
55-	271.28	304.09	195.92	182.37	311.31
60-	544.62	663.34	415.33	364.42	617.27
65-	972.16	1 173.57	756.43	628.30	1 115.97
70-	1 844.30	2 163.77	1 526.95	1 218.95	2 134.68
75-	3 332.55	3 878.53	2 855.14	2 441.07	3 758.14
80-	6 613.36	7 637.94	5 901.62	4 869.03	7 426.14
85-	22 273.49	24 278.07	21 367.74	18 289.22	24 082.95

LE at birth of Chinese population

LE at birth of Chinese population was 73.24 years in 2010, and it was 71.04 years in men and 75.82 years in women. LE was 76.59 years in urban population and 72.08 years in rural population. The LE difference between urban and rural areas was larger in men than that in women (men, 4.97 years *vs* women, 3.93 years). Rural population had a larger gender specific difference in LE than urban population (urban, 3.96 years *vs* rural, 5.00 years).

Impact of CVD Deaths on LE loss in Chinese Population

LE Loss from CVD Deaths The CVD deaths led to 4.79-year loss of LE at birth in Chinese population. Women had more LE loss than men (men, 4.47 years *vs* women, 4.97 years). The LE loss due to CVD deaths in rural population was higher than that in urban population (urban, 4.50 years *vs* rural, 4.88 years) (Table 2).

Contribution of CVD Deaths to LE Loss in Different Age Groups The contribution of CVD deaths in 2010 to LE loss in each age group is listed in Table 3.

Even CVD deaths in age group >65 was a major source of LE loss. Premature CVD deaths were responsible for a substantial part of LE loss from CVD. A total of 34.8% of LE loss in men and 21.7% in women were caused by premature CVD deaths in people aged 25 to 64 years. Premature CVD deaths contributed much more to LE loss in rural areas than in urban areas (urban, 23.3% *vs* rural, 30.7%).

Contribution of Specific CVD Deaths to LE Loss Death from ischemic heart disease and cerebrovascular diseases accounted for 69.2% of LE loss from CVD deaths. And cerebrovascular diseases were the largest contributor to LE loss in men and women, in urban and rural populations. Death from cerebrovascular diseases accounted for 51.1% of LE loss caused by total CVD deaths in rural men and 45.9% of LE loss in rural women compared with 39.2% in urban men and 36.5% in urban women. Death from ischemic heart disease contributed more to LE loss in urban men and women than in rural men and women (Figure 1).

Expected Change in CVD Mortality Required to Increase LE by 1 year LE increased by 0.17, 0.35, 0.53, 0.72, 0.91, and 1.11 years of age when CVD mortality decreased by 5%, 10%, 15%, 20%, 25%, and 30%, respectively. We established a function of the relationship between percentage reduction in CVD mortality and LE, and a linear relationship between the two variables was found. Finally, the percentage that CVD mortality needed to be reduced was evaluated if 1-year LE was increased. According to calculation by function, if there were no changes in mortality rates of all other diseases, a 27.4% reduction in CVD mortality would increase LE by 1 year in Chinese population.

Table 2. Life Expectancy Loss Caused by CVD Deaths by Sex and Area (Years), 2010

Items	Total			Men			Women		
	LE	CVD-eliminated LE	LE Loss by CVD deaths	LE	CVD-eliminated LE	LE Loss by CVD deaths	LE	CVD-eliminated LE	LE Loss by CVD deaths
Total	73.24	78.03	4.79	71.04	75.51	4.47	75.82	80.79	4.97
Urban	76.59	81.09	4.50	74.76	78.89	4.13	78.72	83.43	4.71
Rural	72.08	76.96	4.88	69.79	74.35	4.56	74.79	79.86	5.07

Note. LE, life expectancy.

Table 3. Contribution of CVD Deaths to Life Expectancy Loss by Age Groups, 2010

Age group (years)	Total		Men		Women		Urban		Rural	
	Loss years	Proportion in total LE loss (%)	Loss years	Proportion in total LE loss (%)	Loss years	Proportion in total LE loss (%)	Loss years	Proportion in total LE loss (%)	Loss years	Proportion in total LE loss (%)
0-4	0.0155	0.32	0.0163	0.36	0.0154	0.31	0.0096	0.21	0.0168	0.34
5-14	0.0070	0.14	0.0075	0.17	0.0063	0.13	0.0062	0.13	0.0071	0.15
15-24	0.0284	0.59	0.0335	0.75	0.0215	0.43	0.0259	0.56	0.0289	0.59
25-34	0.0667	1.38	0.0843	1.88	0.0440	0.88	0.0489	1.06	0.0731	1.50
35-44	0.1728	3.57	0.2207	4.93	0.1093	2.20	0.1462	3.17	0.1810	3.70
45-54	0.3762	7.77	0.4468	9.99	0.2759	5.54	0.3029	6.57	0.4078	8.35
55-64	0.7697	15.91	0.8045	17.98	0.6499	13.06	0.5782	12.54	0.8373	17.13
65-74	1.4421	29.81	1.3756	30.74	1.3520	27.18	1.1945	25.92	1.5089	30.88
75-84	1.4276	29.79	1.1791	26.35	1.6799	33.77	1.4562	32.29	1.3938	28.61
85-	0.5325	11.11	0.3063	6.85	0.8208	16.50	0.8402	18.63	0.4323	8.87
Total LE loss	4.7928	100.00	4.4746	100.00	4.9749	100.00	4.5096	100.00	4.8723	100.00

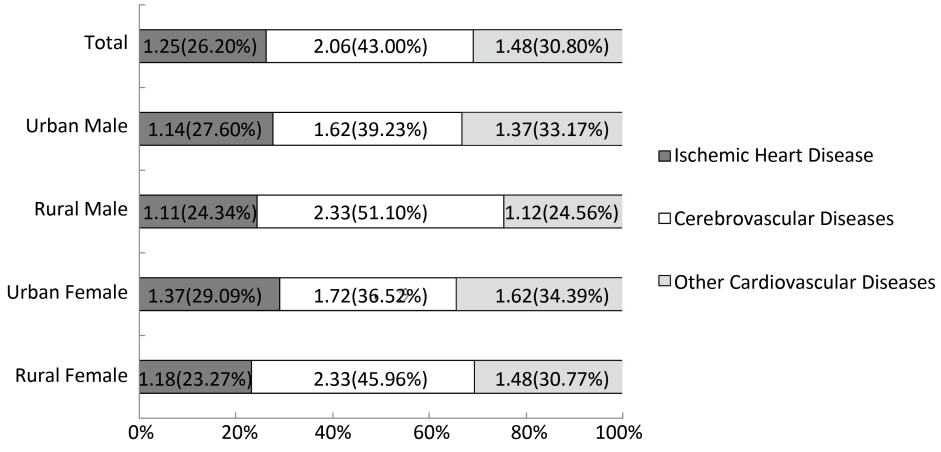

Figure 1. Life Expectancy Loss (years, %) due to deaths of different types of CVD, 2010.

DISCUSSION

This study result indicated that the impact of CVD deaths on LE in China was considerable. With CVD as the cause of death, the loss of LE at birth was 4.79 years for Chinese population. Women had more LE loss than men, and the LE loss due to CVD deaths in rural population was higher than that in urban population. Even CVD deaths in people aged >65 years was a major source of LE loss from CVD. Premature CVD deaths were responsible for a substantial part of LE loss from CVD. Among several types of CVD, death from cerebrovascular diseases led to a major loss in LE, especially for rural population. We also estimated that if there were no changes in the mortality rates of all other diseases, a 27.4% reduction in CVD mortality would increase LE by 1 year in Chinese population in the future.

Loss in LE may explain the degree of the impact on LE by certain causes of death. A few studies have analyzed the impact of major causes of death on LE by using nationwide data in China, but related post-2005 data is lacking[13-14]. Wang's study used data from the Ministry of Health of China, and the results indicated that the LE loss caused by CVD was 4.67 years for men and 4.88 years for women in 2005[13]. Studies have shown that during the past 2 decades the LE loss caused by CVD was approximately 4.5 years for men (range, 2.55-8.23 years) and 5.0 years for women (range, 2.73-10.17 years) in different provinces or regions in China[6-8]. Our study differs from previous studies as follows. We updated the data of the impact of CVD on LE in Chinese population, and explicitly identified the population and type of CVD, which are important for increasing LE in the future. In addition, we estimated the percentage reduction in CVD mortality needed to reach the goal of LE increase set by China government. These findings have important public health implication for the setting of health goals.

The impact of certain death from disease on LE at birth in a population is not only attributed to its total mortality rate but also to mortality distribution in each age group[13]. Our study found that LE loss caused by CVD was 4.47 years and 4.97 years for men and women, respectively. Although men had a higher CVD mortality rate than women, the gender specific differences in mortality in each age group and the different contribution of each age group to LE loss may have led to the fact that women had a higher LE loss than men. Our analysis of age decomposition of LE indicated the population that gave the greatest contribution to LE loss. Notably, premature death from vascular disease (death before 65 years of age) appeared to make a contribution to LE loss. Well-established conventional risk factors for premature CVD death include tobacco use, physical inactivity, unhealthy diet, obesity, diabetes, hypertension, and hyperlipidemia[15-16]. A prospective cohort study with a nationally representative sample of 169 871 Chinese adults found that raised blood pressure is the leading preventable risk factor for premature deaths[17]. Therefore, primary prevention of hypertension should be an important strategy for premature CVD death, and a reduction in dietary salt should be an effective approach for primary prevention of hypertension in China.

Data from the World Health Organization website show that the LE of world population was 68 years in 2009, with the longest LE (83.0 years) in Japan[18]. Chinese people's LE was 5 years longer than the world average level, but there was still a nearly 10-year gap compared with countries with a long LE. Yoshinaga and Une's study[19] found that a dramatic decrease in mortality rate of cerebrovascular diseases gave Japanese the longest life expectancy at birth in the world, and the decline of cerebrovascular disease mortality contributed to an increase in life expectancy at birth of 2.9 years in men and 3.1 years in women from 1970 to 2000. Murray[20] reported that the accelerated mortality decline through public health action and improvement of the management of important risk factors, such as blood pressure, may explain why Japanese life expectancy is so high, indicating the importance of primary prevention of CVD. Our study found that cerebrovascular diseases caused the major LE loss in Chinese population, especially for rural males. In China, there are approximately 1.5 million stroke patients newly diagnosed every year, and approximately 75% of those who survive the acute phase have disabilities[21]. Therefore, more effort should be made to strengthen the prevention, treatment, and rehabilitation of cerebrovascular diseases, as well as reduce the incidence, mortality, and disability rate of cerebrovascular diseases. More attention should also be paid to management and health education about cerebrovascular diseases among rural population, and related prevention and control strategies should be developed for this population.

One limitation of this study is that due to the unavailable of data of under-reporting of death in 2010, we could only use the latest available data to correct the crude death data. Another limitation is that we estimated the percentage of reduction in CVD mortality needed to reach the goal of LE increase. However, LE can be influenced by many other factors (e.g., health care, sanitation, education, nutrition, and GDP)[22]. Therefore, it is difficult to combine all these factors for an accurate estimation of change in LE. In addition, our study involved only Chinese people. Therefore the findings in this study may not be used for other ethnic populations. Additionally, there are many other comprehensive indicators for assessing the burden of disease, such as potential years of life lost, disability-adjusted life years, and disability-adjusted life expectancy. Disability-adjusted life expectancy measures the equivalent number of years of life expected to be lived in full health[23]. Further studies about LE may use these indicators, and focus on how to improve people's health on the basis of increasing LE.

In conclusion, LE at birth is likely to be further increased by reducing deaths caused by CVD. Close attention should be paid to the prevention and control of cerebrovascular diseases, especially in rural population to reach the national goal of health improvement.

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