Premature mortality from four chronic diseases in Wuhai, China and impact on life expectancy, 2015 to 2020

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Abstract

To analyze the change trend of life expectancy, the change trend of premature death due to 4 major chronic diseases, and its impact on the life expectancy of Wuhai residents from 2015 to 2020, and to provide evidence for the prevention and control of chronic diseases in this area. The data on population death comes from the Wuhai City Residents' Causes of Death Network Reporting System and the total population is calculated using statistics from Wuhai City's permanent population management, from 2015 to 2020. Premature mortality from the 4 main chronic illnesses was calculated using the abridged life table approach. The impact of premature death from chronic diseases on life expectancy was analyzed using the Arriaga method. The increasing trend of life expectancy of Wuhai citizens was not statistically significant from 2015 to 2020 ($t = 2.570$, $P = .062$). Each year, men had a lower life expectancy than women ($P < .05$). From 2015 to 2020, the downward trend of premature deaths caused by the 4 major non-communicable diseases in Wuhai City was statistically significant (EAPC = −7.74%, $P = .041$). Premature death from cancer and chronic respiratory disorders decreased, both of which were statistically significant (EAPC < 0, $P < .05$). The decline in premature mortality from cancer, cardiovascular and cerebrovascular disorders, and chronic respiratory system diseases has contributed to increased life expectancy. Diabetes's rise in premature mortality made a possible "negative contribution" to life expectancy (−0.036 years, −1.79%). From 2015 to 2020, the decreasing trend of the overall premature mortality caused by the 4 major non-communicable diseases in Wuhai was statistically significant, and the life expectancy of females was higher than that of males. We should concentrate on the prevention and control of major chronic illnesses in males, as well as the influence of changes in diabetes-related early mortality on life expectancy.

Abbreviations: DEx = direct effect, EAPC = estimating average annual percent change, ICD = International Classification of Diseases, IEx = indirect effect, Ix = interaction effect, NCDs = non-communicable diseases, TEx = total effect, WHO = World Health Organization.

Keywords: chronic disease, decomposition of life expectancy, life expectancy, non–communicable diseases, premature mortality

1. Introduction

Life expectancy is an essential indicator measuring a population's health while it is seriously influenced by non-communicable diseases (NCDs). Chronic illnesses (cardio-cerebrovascular disorders, cancers, diabetes, and chronic respiratory diseases) are the major causes of mortality.[1] According to a World Health Organization (WHO) report, more than 3 million Chinese individuals died before reaching the age of 70 as a result of the 4 categories of major chronic illnesses and other NCDs stated above. The WHO classifies such fatalities as "premature deaths."[2] As WHO and the Chronic Disease

Alliance[3] claimed, 38 percent of chronic illness fatalities globally occurred between the ages of 30 and 70 in 2016, and chronic disease-related premature mortality is regarded as an important indication for assessing regional chronic disease prevention and control. Therefore, it is critical to further study the impact that chronic disease-related early death has on life expectancy growth. This study analyzes the trend of standardized mortality from 4 chronic diseases, the trend of premature death caused by 4 types of chronic diseases and the loss of life expectancy attributed to them using data from the Wuhai City Residents' Causes of Death Network Reporting System and Wuhai City's permanent population census from 2015 to 2020. The trends of premature mortality will serve as an effective approach in chronic illnesses prevention and control by identifying the most prevailing disease and the most vulnerable population in order to achieve the goal set by *the Healthy China* strategy.

2. Data and methods

2.1. Data source

From 2015 to 2020, the data of population death comes from the Wuhai City Residents' Causes of Death Network Reporting System. The major causes of residents' death in Wuhai City were documented according to "International statistical classification of diseases and related health problems" (ICD-10). The 4 major chronic diseases are assigned ICD-10 codes, which include I00-I99 for cardio-cerebrovascular disorders, C00-C97 for cancers, J30-J98 for chronic respiratory diseases, and E10-E14 for diabetes.[4] The total population is calculated by using statistics from Wuhai City's permanent population management from 2015 to 2020.

2.2. Research methods

2.2.1. Abbreviated life table. A population's life expectancy is calculated by the abbreviated life table which divides the population into 19 age groups (0, 1-, 5-, 10-, 15-, ... , 80-, ≥85 years old). To generate the abbreviated life table for the entire population from 2015 to 2020, several mathematical functions and formulae were applied to the calculating programing.[5]

2.2.2. The calculation of premature mortality caused by major chronic diseases.[2] The mortality from 4 main chronic illnesses among Wuhai City people aged 30 to 69 was . The first step is to compute the mortality of inhabitants aged 30 to 69 in every 5-year age group ($^*_5M_x$), and the second step is to determine the probability of death in every 5-year age group ($^*_5q_x$).[6]

$$_5^*M = \frac{\left(\begin{array}{c}\text{number of deaths caused by four types of}\\ \text{chronic diseases of age } x \sim x + n\end{array}\right)}{(\text{total population of age } x \sim x + n)}$$

$$_5^*q = \frac{_5^*Mx \times 5}{1 + _5^*Mx \times 2.5}$$

Then calculate the probability of premature death:

$$^*q_{30} = 1 - \prod_{x=30}^{65} (1 - _5^*qx)$$

2.2.3. The life expectancy contribution decomposition.[7,8] The Arriaga[7] method was adapted to decompose the total effect (TEx) on life expectancy caused by the change in mortality of the age group x ~ x + n into 3 parts: direct Effect (DEx),

indirect effect (IEx) and interaction effect (Ix),[9] where TEx = nDEx + nIEx + nIx.

$$TE_x = \left[\frac{l_x^1}{l_0} \times \left(\frac{L_x^2}{l_x^2} - \frac{L_x^1}{l_x^1}\right)\right] + \left[\frac{T_{x+n}^2}{l_0} \times \left(\frac{l_x^1}{l_x^2} - \frac{l_{x+n}^1}{l_{x+n}^2}\right)\right]$$

TEx stands for the total contribution of age x~x + n, lx for the number of survivors at age x, l_0 for the beginning population in the year superscripted with "1," and lx + n for the number of survivors at age x + n. Tx + n is the total number of survival person-years when the age reaches x + n, and Lx is the number of survival person-years between the age of × to x + n. The superscripts "1" and "2" denote the relevant data in 2015 and 2020, respectively. The early deaths attributed to 1 of the 4 categories of chronic diseases can be calculated as follows:

$$TE_x^i = TE_x \times \left[\frac{R_x^{i,2} - R_x^{i,1}}{S_x^2 - S_x^1}\right]$$

TE_x^i represents the total effect caused by disease "i" of age x~x + n, $R_{_i}^{_×}$ represents the mortality caused by "i" of age x~x + n, and S_x represents the total mortality of age x~x + n.

2.3. Statistical analysis

The time trend of premature mortality rate is analyzed using the estimating average annual percent change (EAPC). A linear regression model is built in which the independent variable "X" is the year (2015–2020), and the dependent variable "y" is the logarithmic conversion value of the rate: y = lg (rate). The EAPC value was calculated based on the regression coefficient "b": EAPC = (10^b–1) × 100%. *T* test of the regression coefficients was conducted to assess the association between EAPC and time with a significance level of *P* < .05.[10] Microsoft Excel and SPSS were used for data collection, analysis, and computation.

The data in this article comes from the Wuhai City Residents' Cause of Death Network Reporting System, and no animal experiments or clinical trials have been conducted, so ethical approval was not required.

3. Results

3.1. Trends in life expectancy in Wuhai from 2015 to 2020

Wuhai citizens' life expectancy was 76.86 years in 2015, and 80.85 years in 2020, respectively; nevertheless, the increased trend was not statistically significant (*t* = 2.570, *P* = .062). Women's life expectancy was 79.70 years in 2015, and 83.51 years in 2020, while 74.44 years and 78.56 years in men; The increasing trend of life expectancy was only significant in men (*t* = 2.796, *P* = .049), which was not found in women (*t* = 2.328, *P* = .080). In each year, men had a lower life expectancy than women, and the difference was statistically significant (*P* < .05) (Table 1).

3.2. Standardized mortality trends of 4 chronic diseases from 2015 to 2020

The mortality rates of 4 chronic diseases (cardiovascular disease, malignant tumor, chronic respiratory disease, and diabetes) in Wuhai City from 2015 to 2020 were standardized, and the results are shown in Figure 1.

3.3. Composition of premature deaths from chronic diseases

In Wuhai, 17,179 people died between 2015 and 2020, with 7047 early fatalities among inhabitants aged 30 to 69,

Table 1

Life expectancy of residents in Wuhai City, 2015 to 2020.

年份	2015	2016	2017	2018	2019	2020	EAPC%	t	P
Males	74.44	76.11	75.08	75.16	76.80	78.56	0.93	2.796	.049*
Females	79.70	81.23	80.08	79.99	81.76	83.51	0.69	2.328	.080
The total population	76.86	78.48	77.47	77.37	79.08	80.85	0.69	2.570	.062

*$P < .05$.

accounting for 41.02 percent of all deaths. The 4 primary chronic illnesses caused 4537 premature deaths among people aged 30 to 69, accounting for 64.38 percent of all premature fatalities. Cancer is the leading cause of mortality among the 4 main chronic illnesses, accounting for 48.12% of all fatalities. The second leading cause of death is cardiovascular and cerebrovascular illnesses, which accounts for 44.26% of all deaths. The number of early deaths among men is higher than the 1 of women for the 4 major chronic illnesses, with a male-to-female mortality ratio of 2.35:1 (3743/1590) (Table 2).

3.4. Trends in premature deaths from chronic diseases

From 2015 to 2020, the overall premature mortality caused by the 4 major NCDs in Wuhai decreased from 18.11% to 11.23%, with a statistically significant decreasing trend (EAPC = −7.74%, $P < .05$);

The decline in premature deaths from cancer and chronic respiratory diseases in male was statistically significant (EAPC < 0, $P < .05$); while the 1 of liver cancer decreased from 2.07% in 2015 to 0.95% in 2020, both of which were statistically significant (EAPC < 0, $P < .05$).

From 2015 to 2020, the downward trend in female premature mortality is statistically significant (EAPC = −7.32%, $P < .05$). Declining trend in premature mortality of cancer-related and cardio-cerebrovascular diseases is statistically significant. (EAPC < 0, $P < .05$) (Table 3).
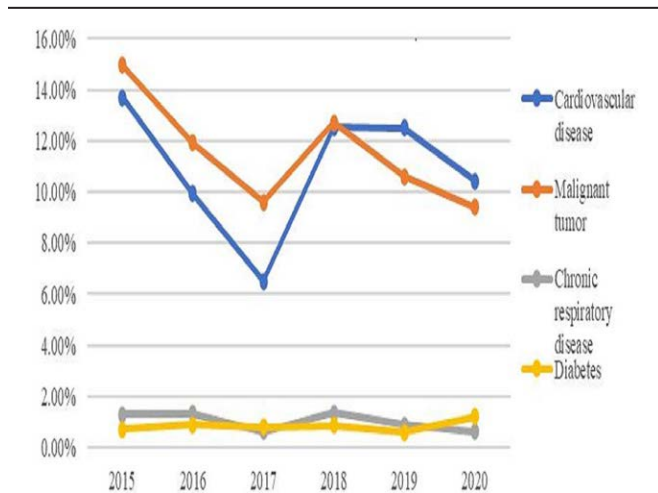

Figure 1. Trend chart of standardized mortality of 4 chronic diseases in Wuhai City from 2015 to 2020.

3.5. The impact of premature death from chronic diseases on life expectancy

The decline of premature mortality form cancer, cardiovascular and cerebrovascular disorders, and chronic respiratory system diseases contributed to increased life expectancy. The drop in cancer-related premature mortality contributed most to the increased life expectancy. The decrease in cardio-cerebrovascular disease-related premature mortality improved life expectancy by 0.643 years, ranking second of the influence on the increased life expectancy. The decline in premature mortality due to cardio-cerebrovascular disorders contributed positively to life expectancy in all age categories, whose effect was highest in those who aged 65 to 69. With the exception of the 50 to 54 years old group (−0.005 years), the reduction in premature mortality induced by chronic respiratory system disorders had a beneficial impact on life expectancy in all other age groups. Diabetes's rise in premature mortality made a possible "negative contribution" to life expectancy (−0.036 years, −1.79%), and it had the smallest impact of the 4 main chronic illnesses.

Among males: the decline in cancer, cardiovascular, and cerebrovascular disease-related premature deaths had a positive contribution to an increase in life expectancy across all age categories. In all age categories except the 50 to 54 years old (−0.009 years), the decline of premature mortality due to chronic respiratory system disorders positively impacted (0.195 years, 8.25%) the life expectancy. The rise in diabetes-related premature deaths had a "negative impact" on life expectancy (−0.038 years, −1.59%).

Among females: The decline in premature deaths from cardiovascular and cerebrovascular disorders had a positive contribution to life expectancy, accounting for the biggest impact (0.718 years, 41.36%). In all age categories except the 40 to 44 years old (−0.001 years), the decline in cancer-related premature mortality had a positive impact (0.697 years, 40.15%) on life expectancy. The decline in premature mortality due to chronic respiratory system disorders had a positive contribution to life expectancy for people of all ages (0.004 years, 0.21%). The rise in diabetes-related premature death had a "negative impact" on life expectancy (−0.035 years, −2.03%) (Table 4).

4. Discussion

The death pattern of Wuhai has changed dramatically as a result of rapid economic development, changes in people's lifestyles, and improvements in medical standards: the mortality of infectious diseases has been decreasing while the 1 of chronic diseases has been increasing, and this a phenomenon was known as the "population health transition" process.[11]

Table 2

Absolute number of premature deaths according to 4 major chronic diseases in Wuhai, 2015 to 2020.

	2015	2016	2017	2018	2019	2020	Overall	Percentage (%)
Cardiovascular diseases	449	327	377	417	438	383	2008	44.26
Cancer	490	393	509	423	368	345	2183	48.12
Chronic respiratory diseases	36	41	45	39	32	23	213	4.69
Diabetes	21	23	28	27	22	45	133	2.93

Table 3

The probability of premature death (%) and trend of 4 major chronic diseases of residents in Wuhai, 2015 to 2020.

Non-communicable diseases		2015	2016	2017	2018	2019	2020	EAPC (%)	t	P
The total population	Cardiovascular diseases	8.44	5.8	6.94	7.26	6.26	5.21	−6.03	−1.784	.149
	Cancer	9.36	7.13	9.05	7.44	5.68	5.32	−10.05	−3.251	.031*
	Lung cancer	2.48	2.12	2.69	2.40	1.63	1.34	−10.87	−2.519	.065
	Liver cancer	1.30	1.39	1.64	1.03	0.55	0.70	−16.44	−2.64	.058
	Gastric cancer	1.18	1.08	1.26	1.07	0.69	0.93	−7.32	−1.792	.148
	Others	4.71	2.73	3.75	3.14	3.09	2.45	−8.38	−1.989	.118
	Chronic respiratory diseases	0.84	0.92	1	0.8	0.52	0.4	−14.89	−3.032	.039*
	Diabetes	0.48	0.57	0.51	0.53	0.32	0.69	0.46	0.051	.962
	Overall	18.11	13.82	16.64	15.31	12.34	11.23	−7.74	−2.961	.041*
Males	Cardiovascular diseases	10.88	8.29	9.73	10.9	9.2	7.53	−4.06	−1.187	.301
	Cancer	12.61	9.66	12.87	10.01	7.74	7	−10.46	−3.003	.04*
	Lung cancer	3.80	3.16	4.30	3.61	2.46	2.15	−10.26	−2.292	.084
	Liver cancer	2.07	2.18	2.65	1.34	0.89	0.95	−18.72	−3.177	.034*
	Gastric cancer	1.67	1.50	2.27	1.64	1.06	1.53	−4.94	−0.86	.438
	Others	5.66	3.16	4.31	3.79	3.81	2.55	−9.64	−1.969	.12
	Chronic respiratory diseases	1.53	1.44	1.71	1.3	0.73	0.61	−17.96	−3.441	.026*
	Diabetes	0.56	0.84	0.59	0.6	0.26	0.82	−4.50	−0.410	.703
	Overall	23.75	19.04	23.16	21.34	17.05	15.22	−7.32	−2.648	.057
Females	Cardiovascular diseases	6.04	3.37	4.18	3.63	3.18	2.72	−11.49	−3.010	.04*
	Cancer	6.4	4.76	5.4	5.09	3.75	3.69	−9.64	−3.700	.021*
	Lung cancer	1.31	1.10	1.23	1.29	0.85	0.58	−12.70	−2.684	.055
	Liver cancer	0.54	0.66	0.66	0.72	0.21	0.44	−11.69	−1.181	.303
	Gastric cancer	0.70	0.69	0.33	0.54	0.34	0.37	−13.10	−2.217	.091
	Others	3.97	2.39	3.26	2.62	2.47	2.34	−7.53	−1.95	.123
	Chronic respiratory diseases	0.21	0.44	0.40	0.32	0.32	0.19	−4.72	−0.550	.612
	Diabetes	0.40	0.33	0.45	0.47	0.37	0.56	6.17	1.457	.219
	Overall	12.60	8.69	10.12	9.26	7.45	7.01	−9.43	−3.585	.023*

*$P < .05$.

Table 4

The life expectancy contribution decomposition of 4 major chronic diseases in Wuhai city (TEi), 2015 to 2020.

	Age group	30-	35-	40-	45-	50-	55-	60-	65–69	Overall	Percentage (%)
The total population	Cardiovascular diseases	0.024	0.012	0.063	0.006	0.070	0.020	0.195	0.254	0.643	31.57
	Cancer	0.026	0.040	0.046	0.041	0.262	0.151	0.172	0.205	0.942	46.30
	Chronic respiratory diseases	0.014	0.010	0.015	0.010	−0.005	0.012	0.036	0.014	0.105	5.16
	Diabetes	0.007	−0.004	0.006	−0.008	0.001	−0.020	−0.004	−0.014	−0.036	−1.79
Males	Cardiovascular diseases	0.030	0.022	0.087	0.012	0.043	0.019	0.127	0.274	0.615	26.02
	Cancer	0.037	0.032	0.082	0.022	0.299	0.181	0.261	0.265	1.179	49.88
	Chronic respiratory diseases	0.024	0.019	0.026	0.018	−0.009	0.022	0.068	0.027	0.195	8.25
	Diabetes	0.012	0.000	0.005	−0.014	−0.002	−0.008	−0.022	−0.010	−0.038	−1.59
Females	Cardiovascular diseases	0.016	0.002	0.032	0.002	0.101	0.036	0.288	0.241	0.718	41.36
	Cancer	0.011	0.050	−0.001	0.065	0.203	0.120	0.094	0.155	0.697	40.15
	Chronic respiratory diseases	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.004	0.21
	Diabetes	0.000	−0.010	0.007	0.000	0.005	−0.036	0.015	−0.017	−0.035	−2.03

Life expectancy is a comprehensive indicator to measure the current level of economic and social development and the level of medical and health services of a country or region. Before the founding of New China, China's average life expectancy was only 35 years, less than half of what it is now. Maternal mortality and infant mortality are important factors affecting life expectancy. Deaths caused by the 4 major chronic illnesses have significantly influenced the shift of Wuhai's life expectancy. People in Wuhai had a life expectancy of 80.85 years in 2020, which was higher than the national average (77.4 years)[12] and even comparable to the 1 of high-income countries (80.9 years in 2019)[13] although the capital of China, Beijing, had achieved this level of life expectancy (80.81 years) ten years ago.[14] Men and women in Wuhai have significantly different life expectancy from 2015 to 2020, with women enjoying a higher life expectancy each year. This is conformed to the findings from a systematic assessment on the present situation of the application of healthy life expectancy indicators for Chinese residents,

which indicated that in most studies, men had a lower healthy life expectancy than women.[15] Men, in comparison to women, face greater societal pressure and hazardous living behaviors, and the prevalence of smoking and binge drinking are higher than women.[15–18] In Wuhai, considerable variations existed in the premature mortality due to the 4 major chronic illnesses between men and women from 2015 to 2020, and the risk of premature death among men was 2.35 times as high as the 1 in women, which was consistent with another research on the risk of premature death of the 4 major chronic illnesses in China from 1990 to 2015.[19] As a result, we must concentrate on the prevention and management of the chronic illnesses among men.

The abridged life table approach was used to calculate the probability of premature death for 4 chronic conditions. Because this index is unaffected by the age composition of the population and can be compared across regions and time periods, WHO recommends it as a key indicator for assessing

the extent of chronic illness control in a country.[2] From 2015 to 2020, 7047 premature deaths occurred in Wuhai (41.02% of total deaths), 4537 of which were caused by the 4 major chronic diseases (64.38% of premature deaths), indicating that the 4 major chronic diseases were the leading causes of premature deaths among Wuhai residents. The probability of premature death of the 4 major chronic diseases has dropped from 18.11% in 2015 to 11.23% in 2020, which is lower than the national average (18.54% in 2015)[19] but higher than some economically developed areas in China (Hexi District of Tianjin[20]: 11.24 % in 2015, 10.23% in 2019; Putuo District of Shanghai[21]: 9.65% in 2015, 9.11% in 2019), suggesting that Wuhai has achieved remarkable improvement in the prevention and control of chronic diseases during recent years while the gap still exists. The degree of decline in the premature mortality caused by the 4 major chronic illnesses of Wuhai from 2015 to 2020 was higher than that of Chongqing municipality (2015: 15.72%, 2019: 13.94%)[17] and Anhui Province (2014: 15.53%, 2018: 14.43%).[11] One possible explanation for Wuhai's magnitude achievement in reducing the premature death is that the risk of premature mortality from the 4 major chronic illnesses was rather high in 2015, a lot of aspects could have been improved by means of chronic disease prevention strategies, disease control policies and programs. Life expectancy is affected by changes in mortality.[12] We applied the Arriaga approach to decompose the contribution of the 4 major diseases-related the premature mortality decline to the increase in life expectancy in this study, respectively. The decline in the premature mortality of major chronic diseases such as cardiovascular diseases and cancer was found to be the cardinal factor propelling the increase of life expectancy, which is consistent with another similar research on premature mortality caused by the same 4 major NCDs and its impact on life expectancy in Wuxi, 2008 to 2018.[6]

The influence of premature mortality induced by the 4 main chronic illnesses (cardio-cerebrovascular diseases, cancer, chronic respiratory disorders, and diabetes) on life expectancy was conducted a further quantitative analysis in this study. The findings revealed that the decline in cancer and cardio-cerebrovascular diseases related premature mortality had a significant impact on the improvement of life expectancy, which resulted in an additional 1.585-year in average specifically and accounted for 77.87% of the total increase. The decline in premature death of chronic respiratory diseases had a positive contribution to the increase in life expectancy, which enabled the life expectancy to increase by 0.105 years, which accounted for 5.16%. Although the mortality rate of chronic respiratory diseases was higher, the probability of premature death was lower, and the possible reason was that the age of both onset and death was relatively late, and it mainly affected the elderly.[22,23] Changes in the probability of premature death of diabetes had a "negative influence" on life expectancy, which led the life expectancy to reduce by 0.036 years (accounting for –1.79% of the total increase in life expectancy). The monitoring report on chronic diseases and their risk factors of China in 2010 stated that the prevalence of diabetes was 11.6% among Chinese adults (18 years of age and above) and 10.7% in 2013, therefore, it can be inferred that the number of diabetes patients among Chinese adults is 114 million.[24] According to a study by Liu and her colleagues, the probability of premature death from diabetes in China will increase by 50.0% in 2030 compared with 2013 based on the natural trend of risk factors.[25,26] At present, although diabetes-related premature mortality is not the leading cause of death, the increasing trend must be considered seriously. Between 2000 and 2016, premature deaths from diabetes increased by 5%. By 2019, diabetes was the ninth leading cause of death, with an estimated direct cause of 1.5 million deaths.

This research still has several limitations. Only the impact of the 4 major chronic diseases did the study include in the research;

it doesn't take other chronic diseases into consideration; thus, it cannot reflect how other chronic diseases affect life expectancy. In addition, several possibly confounding factors such as economic growth, socio-political issues, and people's life habits will also influence life expectancy.[6] The influence of appeal considerations on life expectancy could not be assessed in this study because it only looked at the cause of death.

5. Conclusion

In summary, the standardized mortality rate of 4 chronic diseases and the decline in premature mortality of 4 chronic diseases among the total population of Wuhai City are statistically significant from 2015 to 2020; the decline in the premature death of cancer, cardiovascular and cerebrovascular diseases and chronic respiratory system diseases made a positive contribution to life expectancy; the increase in the premature death of diabetes had a "negative contribution" to life expectancy. Women's life expectancy is higher than that of men. We should concentrate on the prevention and control of major chronic illnesses in males, as well as the influence of changes in diabetes-related early mortality on life expectancy. It is of great importance that to identify the primary risk factors which must be addressed in order to reduce the population's exposure to risk factors. To raise residents' life expectancy and to achieve the strategic aim of *Healthy China*, the premature mortality caused by chronic illnesses should be controlled in the region.

Author contributions

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