Evaluation of Impact of Major Causes of Death on Life Expectancy Changes in China, 1990-2005

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Objective To evaluate the impact of major causes of death on changes of life expectancy in China. **Methods** Life expectancy was calculated by standard life table techniques using mortality data from the national censuses in 1990 and 2000 and the 1% National Population Sampling Surveys in 1995 and 2005. Mortality data about the major causes of death from VR-MOH were used as reference values to estimate their death proportions of the specific age groups by sex and regions, as well as all-cause mortality and age-specific mortality rates of major causes of death. Decomposition method was used to quantitatively evaluate the impact. **Results** Three key findings were identified in our study. First, China's health challenge was shifted from diseases related to living conditions to those related to behavior and lifestyle, with rural areas relatively lagged behind urban areas. Second, the impacts of cardiovascular diseases and neoplasm on the middle aged and elderly population were stressed. Third, compared to the urban population, the rural population tended to have increasing mortality of neoplasm and cardiovascular diseases, especially in adults at the age of 15-39 years. **Conclusion** Further efforts should be made to reduce the incidence of neoplasm and cardiovascular diseases, especially in rural areas, by promoting healthy behavior and lifestyle and providing appropriate therapies for all patients in need.

Key words: China; Life expectancy; Cardiovascular disease; Neoplasm

INTRODUCTION

Since the implementation of market-oriented reform in 1978, China has made great progress in economic development, with the average annual GDP growth rate reaching 9.4%[1]. Progress has also been achieved in health care since the 1970s with the life expectancy at birth gaining approximately 6-7 years in 2000 (69.63 years of males and 73.33 years of females)[2]. However, the process of changing life expectancy remains slow in contrast to the rapid economic development, and there is a severe health gap between geographic or economic regions in this country. The urban-rural disparity in life expectancy increased from 3 years to 5 years of males in 1981 and from 4 to 5 years of females in 2000[3], and residents in provinces with the lowest rural population have a better life expectancy[1]. While the incidence of infectious diseases is staggering at a relatively higher level in China, risks to chronic diseases including cardio-vascular diseases and cancers tend to increase due to lifestyle changes synchronized with industrialization and urbanization[4]. Evaluation of the impact of communicable and non-communicable diseases on life expectancy is an essential part of public health services and can obtain more information concerning the main health problems, determinants of health and most vulnerable population groups in the course of the economic development, and can also provide valuable data for the formulation of public health policies and the improvement of the effectiveness of health investments and resource allocation. Since few studies are available and no coherent systems can be utilized to register deaths, this study is designed to quantitatively evaluate the impact of major causes of death on life expectancy in this country.

MATERIALS AND MEDTHODS

Data Source

The data concerning the total number of deaths

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and crude death rates were obtained from the national censuses in 1990[5] and 2000[6], the 1% National Population Sampling Surveys in 1995[7] and 2005[8], which were published by the National Bureau of Statistics of China.

Estimation of Mortality of Major Causes of Death

The census and sampling survey could not provide information on the causes of death. By comparing the mortality data from the census (or sampling survey) and the data from the Ministry of Health Vital Registration System (VR-MOH), we found that there were no significant differences in the crude mortality rates, proportions of deaths at age 0-4, 5-14, 15-39, 40-64, and 65 years or over nor in the mortality sex ratios (P>0.05, Table 1). So we used the mortality data of major causes of death from VR-MOH as a reference value to estimate the proportions of major causes of death in the specific age groups by sex and regions. Subsequently, we postulated that most of the urban and rural definitions were identical in VR-MOH, the 1990[5] and 2000 Censuses[6] and the 1995[7] and 2005 Surveys[8], and that the urban and rural mortality patterns in VR-MOH were in line with those in the 1990[5] and 2000 Censuses[6] and the 1995[7] and 2005 Surveys[8] in the same year. Based on these presuppositions, we used the mortality data derived from the above Censuses and Surveys, as well as the proportions of causes of death from VR-MOH to estimate the mortality attributable to causes of death in specific age groups, sex and areas in respective years of 1990, 1995, 2000, and 2005.

TABLE 1

Comparison of Crude Mortality, Sex Ratio and Proportion of Deaths in Age Groups between Data from the Census (or Sampling Survey) and Those from VR-MOH

	1990		1995		2000		2005	
	Census*	VR-MOH†	1% Sampling*	VR-MOH†	Census*	VR-MOH†	1% Sampling*	VR-MOH†
Crude Mortality(‰)	5.90	6.14	6.45	6.17	5.92	6.08	6.00	5.37
Sex Ratio	106	104	104	104	106	104	102	104
Proportion of deaths in Age Groups:								
0-4	0.11	0.10	0.09	0.05	0.06	0.03	0.03	0.02
5-14	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01
15-39	0.11	0.08	0.10	0.07	0.09	0.07	0.07	0.05
40-64	0.27	0.24	0.26	0.26	0.25	0.26	0.26	0.25
≥65	0.50	0.56	0.54	0.61	0.59	0.63	0.63	0.68
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note. *Source: National Statistical Bureau of China[5-8]. †Calculated by authors according to the data from the Ministry of Health Vital Registration System.

Major Causes of Death Coding

Causes of death in MOH-VR are coded by ICD-9 (from 1987 to 2001) and ICD-10 (since 2002), in which variations are more likely to lead to comparable problems when more precise categories are used. In order to minimize this effect, we used broad diagnostic groups. Major causes of death in our study included infectious and parasitic diseases (ICD-9 codes 001-139, ICD-10 codes A00-B99), neoplasm (ICD-9 codes 140-208 and 230-234, ICD-10 codes C00-D48), coronary heart disease (CHD) (ICD-9 codes 410-414; ICD-10 codes I20-I25), cerebrovascular disease (CVD) (ICD-9 codes 430-438; ICD-10 codes I60-I69), respiratory disease (ICD-9 codes 460-519; ICD-10 codes J00-J98), injury and poison (ICD-9 codes E800-E999; ICD-10 codes V01-Y98).

Method of Calculating Life Expectancy

Life expectancy at birth was calculated using standard life table techniques[9]. Decomposition of life expectancy was undertaken to quantitatively evaluate the impact of major disease-specific deaths as previously described[10-11].

The formulas below describe the decomposition of life expectancy at age α between two populations or time points in Arriaga's method. ${}_iTE_x$ denotes the

total contribution of mortality changes to life expectancy for the age interval (x, x+i) to age α between time t and time t+n or between the rural and urban populations in the same year. ${}_iDE_x$ denotes the direct contribution, ${}_iIE_x$ the indirect contribution and ${}_iI_x$ the interaction contribution. l_x^t and T_x^t are the general terms in life table. The former refers to the number of persons reached age x at time t, whereas the latter refers to the total person-years lived from age x and above.

$$ {}_iDE_x = l_x^t({}_ie_x^{t+n} - {}_ie_x^t) \Big/ l_a^t = \left(l_x^t \Big/ l_a^t\right) \times \left[(T_x^{t+n} - T_{x+i}^{t+n}) \Big/ l_x^{t+n} - (T_x^t - T_{x+i}^t) \Big/ l_x^t \right] $$

$$ {}_iIE_x = {}_iCS_x \times e_{x+i}^t \Big/ l_a^t = \left(T_{x+i}^t \Big/ l_a^t\right) \times \left(l_x^t \times l_{x+i}^{t+n} \Big/ l_{x+i}^t \times l_x^{t+n} - 1 \right); \qquad {}_iCS_x = \left(l_x^t \times l_{x+i}^{t+n} \Big/ l_x^{t+n} \right) - l_{x+i}^t $$

$$ {}_iI_x = {}_iOE_x - {}_iIE_x; \qquad {}_iOE_x = {}_iCS_x \times e_{x+i}^{t+n} \Big/ l_a^t = \left(T_{x+i}^{t+n} \Big/ l_a^t\right) \times \left(l_x^t \Big/ l_x^{t+n} - l_{x+i}^t \Big/ l_{x+i}^{t+n} \right) $$

$$ {}_iTE_x = {}_iDE_x + {}_iIE_x + {}_iI_x $$

For the open end age interval (i.e. the last age-group), there is only a direct effect:

$$ DE_{x+} = l_x^t \Big/ l_a^t \left(T_x^{t+n} \Big/ l_x^{t+n} - T_x^t \Big/ l_x^t \right) $$

Arriaga assumed that the number of deaths from cause α occurring in the age group x to x+n is proportional to the total number of deaths occurring in the same age group. That is to say, the total effect, ${}_nTE_{x(\alpha)}$, from cause α occurring in the interval [x, x+n] is equal to the total effect(${}_nTE_x$) times a factor(${}_nk_{\alpha x}$), which is given by

$$ {}_nTE_{x(\alpha)} = {}_nTE_x \times {}_nk_{\alpha x} $$

where,

$$ {}_nk_{\alpha x} = ({}_nm_{\alpha x}^b - {}_nm_{\alpha x}^a) \Big/ ({}_nm_x^b - {}_nm_x^a) $$

In our study, the gain was defined as the increase in life expectancy at birth from 1990 to 2005. Definition of the gap between urban and rural areas was the disparity in life expectancy, with positive (or negative) value to indicate that life expectancy was higher (or lower) in the urban areas.

RESULTS

Changes in Life Expectancy

From 1990 to 2005, the life expectancy in both men and women saw an upward trend with more gains achieved in the urban population. The gaps between urban and rural areas in males increased from 2.06 years in 1990 to 5.07 years in 2000, and then decreased to 4.87 years in 2005. Similar results were also observed in females (Table 2).

Contributions to Gains of life Expectancy

In the urban population, CVD was the prominent contributor to the gains (19.85% in men, 18.60% in women), followed by respiratory diseases (15.12% in men, 16.32% in women) and neoplasm (17.85% in men, 13.15% in women). The mortality improvement in middle-aged and elderly population accounted for over two thirds of the increments of life expectancy in both males and females during the last fifteen years, while the contribution of infectious and parasitic diseases was only 5.25% in males and 3.46% in females (Table 3).

In the rural population, respiratory diseases were the leading contributor to the gains, accounting for 37.22% and 44.96% of the overall gains in males and females, followed by mortality decline of infectious and parasitic diseases in both sexes, injury and poison in women. Besides the middle-aged and elderly population, children under the age of 5 years also played an important role in the improvement of life expectancy in both sexes (Table 3).

Moreover, higher CVD and neoplasm mortality rates in rural residents aged 15-39 years in 1995, 2000 and 2005 offset the part of improvements in life expectancy, with the ratios showing an obvious upward trend in contrast to those in 1990 (Fig. 1).

Contributions to Urban-rural Gap of Life Expectancy

In 1990-2005, the leading contributors of causes of death to the urban-rural gap of life expectancy were gradually shifted from respiratory diseases, injury and poison, infectious and parasitic diseases to neoplasm and cardiovascular diseases in both sexes (Tables 4 and 5). Using males as an example, the contribution of respiratory diseases, injury and poison, infectious and parasitic diseases to the gap was decreased from 70.57% to 21.43%, from 36.35% to 27.10%, and from 13.66% to 1.68%, respectively, during the study period. At the same time, the contribution of these diseases to the gap was decreased from 41.61% in 1990 to 12.49% in 2005 in children under the age of 5 years (from 34.58% in 1990 to 20.82% in 2005 in females).

TABLE 2

Mortality Rates by Age Groups, Areas, and Sex and Life Expectancy at Birth in 1990, 1995, 2000, and 2005 (Per 100000)

Age Groups	Urban-Males				Rural-Males				Urban-Females				Rural-Females			
	1990	1995	2000	2005	1990	1995	2000	2005	1990	1995	2000	2005	1990	1995	2000	2005
<1	1683.27	1654.69	1079.24	756.40	2562.72	3172.42	2828.32	1396.41	1892.24	1804.09	1441.68	808.58	2881.72	4396.41	4115.52	1855.12
1-	165.90	115.81	72.66	55.88	262.00	203.44	181.47	98.71	160.40	122.46	65.43	39.56	274.83	185.77	188.31	112.58
5-	74.42	53.54	41.98	39.45	94.96	78.91	73.73	62.12	50.33	39.84	26.54	18.53	72.18	63.62	51.34	35.23
10-	60.05	50.93	37.68	32.10	73.10	64.62	55.70	58.33	42.75	33.89	21.59	20.24	57.11	49.31	38.02	31.87
15-	96.25	93.58	42.55	51.83	120.70	116.14	101.14	113.37	73.32	53.77	23.41	25.28	101.57	86.56	65.87	59.16
20-	129.09	137.66	75.13	70.50	155.67	178.86	155.43	184.68	96.50	65.27	36.06	25.40	139.96	145.21	100.39	78.50
25-	127.44	143.36	88.36	85.50	158.44	191.60	168.77	202.84	91.49	75.66	43.37	29.37	140.25	135.05	112.93	94.83
30-	156.32	161.85	114.42	100.73	194.22	210.53	198.97	248.48	108.27	73.75	56.82	42.46	158.25	138.39	124.00	116.27
35-	206.76	173.97	158.12	148.89	247.42	267.15	255.84	280.61	136.07	101.29	76.89	65.33	189.43	168.66	146.73	141.46
40-	303.55	256.90	240.13	223.11	359.13	358.89	349.72	369.57	201.79	135.23	120.49	91.91	263.54	230.96	203.72	161.65
45-	468.15	403.48	350.80	355.77	542.32	527.48	480.30	499.28	313.19	251.93	187.35	163.66	393.51	328.24	297.79	268.83
50-	758.44	707.87	544.33	502.25	860.57	779.20	738.40	648.21	501.86	412.45	316.40	268.26	615.82	542.64	475.06	371.93
55-	1245.81	1076.26	863.88	728.35	1388.62	1325.23	1155.14	992.63	787.07	617.75	503.26	432.51	934.06	863.09	752.08	585.06
60-	2145.31	1812.56	1447.15	1202.78	2343.69	2232.23	1974.98	1580.54	1331.72	1065.92	885.36	722.38	1557.33	1313.67	1293.86	1024.79
65-	3480.33	3043.74	2480.18	2019.59	3730.38	3517.51	3216.53	2620.21	2172.22	1860.70	1537.08	1223.55	2494.78	2254.77	2102.18	1742.16
70-	5742.13	5013.86	4289.80	3240.62	6101.32	5624.95	5515.72	4412.07	3719.16	3166.74	2776.62	2039.70	4251.11	4024.84	3713.98	3015.06
75-	8461.00	7407.85	6834.24	5358.16	8921.39	8442.90	8528.04	6981.15	5709.71	5281.89	4605.52	3683.19	6441.67	6103.26	6001.44	5105.30
80-	13285.29	11113.90	11372.54	8511.90	14040.97	13118.57	14226.13	11106.04	9416.34	8733.77	8153.16	6493.31	10508.38	10111.02	10459.94	8310.93
85+	20161.02	18733.15	17909.72	15637.90	20347.20	19473.32	21693.82	18583.45	15870.36	14612.00	14993.96	12415.00	16526.40	16584.22	18028.84	15259.92
Crude Mortality Rates	590.40	620.64	482.38	528.05	678.55	731.43	739.79	803.27	496.81	475.74	373.41	382.78	602.55	631.97	630.69	629.25
e_0	70.05	71.61	74.14	76.45	67.99	68.18	69.07	71.58	74.5	76.56	78.62	81.64	71.49	71.61	72.51	76.51

TABLE 3

Contributions of Major Causes of Death to Life Expectancy Gains from 1990 to 2005 in China (Years)

Age Groups	All	Infect & Parasitic	Neoplasm	CHD	CVD	Respiratory	Injury & Poison
Urban							
Males 0-4	1.0174 (***15.89%***)	0.0418	0.0315	-0.0012	-0.0085	0.1688	0.1366
5-14	0.2070 (***3.23%***)	0.0135	0.0308	-0.0006	-0.0013	0.0099	0.0835
15-39	0.6175 (***9.65%***)	0.0610	0.0920	0.0082	0.0097	0.0146	0.2036
40-64	1.8071 (***28.23%***)	0.1162	0.5785	0.1579	0.3842	0.1742	-0.001
65+	2.7527 (***43.00%***)	0.1033	0.4097	0.2458	0.8866	0.6006	0.0529
All	6.4017 (***100.00%***)	0.3359 (***5.25%***)	1.1426 (***17.85%***)	0.4101 (***6.41%***)	1.2707 (***19.85%***)	0.9681 (***15.12%***)	0.4756 (***7.43%***)
Females 0-4	1.2451 ***(17.44%)***	0.0594	0.0313	-0.0011	-0.0035	0.2347	0.1600
5-14	0.1926 ***(2.70%)***	0.0074	0.0281	-0.0006	0.0004	0.0102	0.0627
15-39	0.8339 ***(11.68%)***	0.0521	0.1617	0.0065	0.0148	0.0234	0.2770
40-64	1.7829 ***(24.98%)***	0.0614	0.4209	0.1237	0.3770	0.1778	0.0319
65+	3.0835 ***(43.20%)***	0.0669	0.2965	0.2270	0.9392	0.7188	0.1104
All	7.1380 ***(100.00%)***	0.2472 ***(3.46%)***	0.9384 ***(13.15%)***	0.3554 ***(4.98%)***	1.3279 ***(18.60%)***	1.1649 ***(16.32%)***	0.6420 ***(8.99%)***
Rural							
Males 0-4	1.2579 (***34.98%***)	0.0863	-0.0094	-0.0019	-0.0108	0.4638	0.2752
5-14	0.1463 (***4.07%***)	0.0377	-0.0052	0.0000	-0.0014	0.0251	0.0397
15-39	-0.3131 (***-8.71%***)	0.0854	-0.1140	-0.0043	-0.0425	0.0219	-0.2698
40-64	1.0743 (***29.88%***)	0.1745	0.1849	0.0249	0.0329	0.3854	-0.0578
65+	1.4304 (***39.78%***)	0.1345	0.0066	0.0217	0.1964	0.7203	0.0419
All	3.5958 (***100.00%***)	0.5184 (***14.42%***)	0.0629 (***1.75%***)	0.0403 (***1.12%***)	0.1746 (***4.85%***)	1.6165 (***44.96%***)	0.0292 (***0.81%***)
Females 0-4	1.2376 (***24.62%***)	0.1071	-0.0147	-0.001	-0.0133	0.6031	0.3039
5-14	0.2051 (***4.08%***)	0.0387	0.0018	-0.0012	-0.0028	0.0355	0.0802
15-39	0.5823 (***11.58%***)	0.0935	-0.0222	0.0038	-0.0114	0.0376	0.3370
40-64	1.4271 (***28.39%***)	0.1412	0.2145	0.0416	0.1186	0.3816	0.0819
65+	1.5753 (***31.33%***)	0.1097	0.0363	-0.0355	0.2885	0.8133	0.0599

All	5.0273 (***100.00%***)	0.4901 (***9.75%***)	0.2157 (***4.29%***)	0.0078 (***0.16%***)	0.3796 (***7.55%***)	1.8712 (***37.22%***)	0.8630 (***17.17%***)

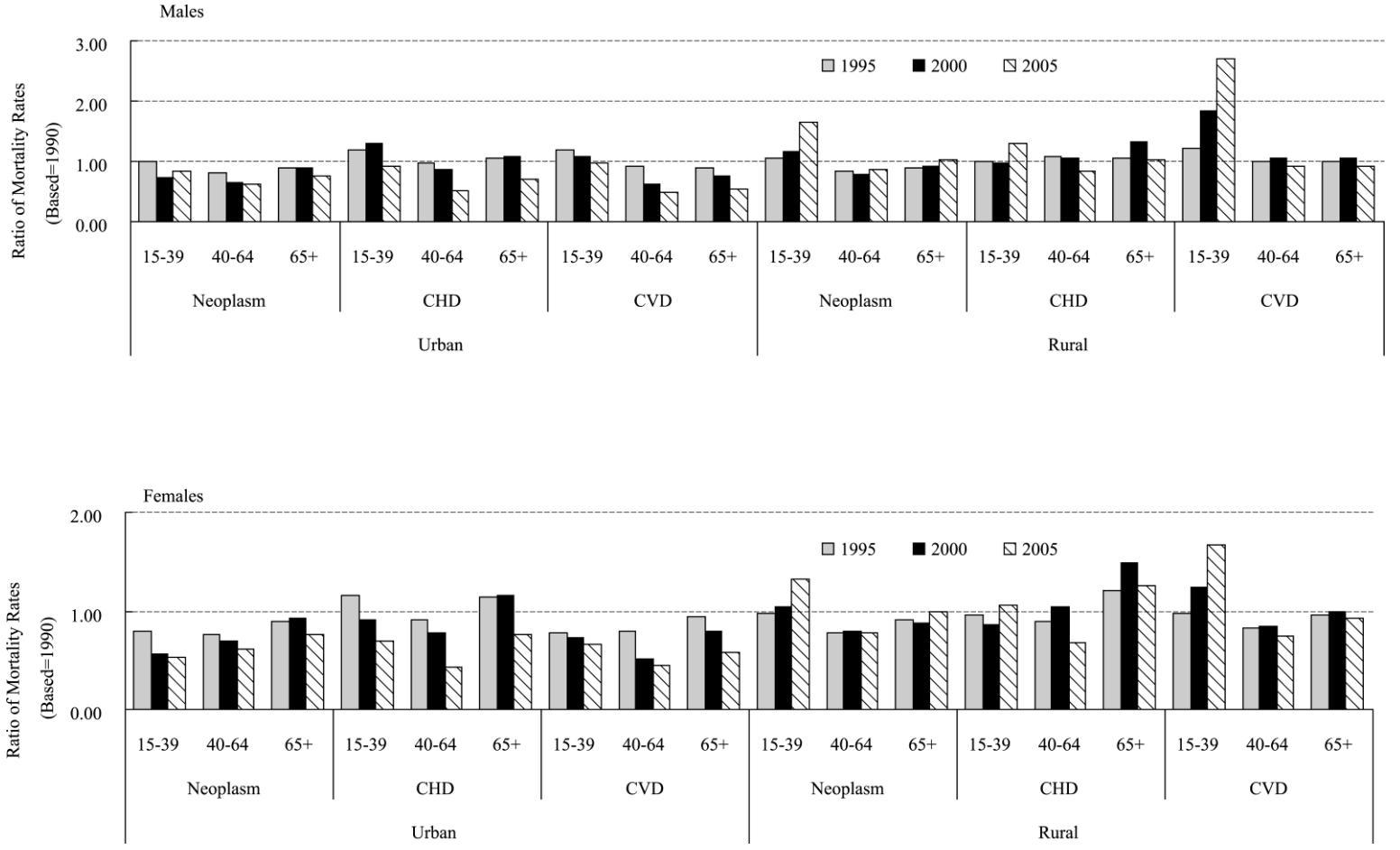

FIG.1. Mortality Rates for Neoplasm, CHD, and CVD in Populations Aged 15 Years or Older by Age groups and Sex.

TABLE 4

Contributions of Major Causes of Death to Gaps of Life Expectancy between Urban and Rural Areas of China (Years, Males)

Age Groups	All	Infectious & Parasitic Diseases	Neoplasm	CHD	CVD	Respiratory Diseases	Injury & Poison
1990							
0-4	0.8578 (***41.61%***)	0.0688	-0.0294	0.0000	0.0000	0.3951	0.2709
5-14	0.1007 (***4.89%***)	0.0267	-0.0191	-0.0005	0.0000	0.0226	0.0805
15-39	0.3320 (***16.10%***)	0.0481	0.0276	0.0096	-0.0092	0.0276	0.1943
40-64	0.4864 (***23.59%***)	0.0795	0.1093	-0.1249	-0.1475	0.3645	0.1550
65+	0.2849 (***13.82%***)	0.0584	-0.1993	-0.2463	-0.1119	0.6452	0.0487
All	2.0617 (***100.00%***)	0.2816 (***13.66%***)	-0.1109 (***-5.38%***)	-0.3621 (***-17.56%***)	-0.2686 (***-13.03%***)	1.4550 (***70.57%***)	0.7494 (***36.35%***)
1995							
0-4	1.2951 (***37.67%***)	0.0532	-0.0115	-0.0003	0.0011	0.6004	0.2722
5-14	0.1198 (***3.48%***)	0.0139	-0.0156	0.0002	-0.0012	0.0248	0.1083
15-39	0.5202 (***15.13%***)	0.0582	0.0487	0.0045	-0.0068	0.0721	0.2851
40-64	0.8319 (***24.20%***)	0.0914	0.1758	-0.1099	-0.0881	0.4402	0.2018
65+	0.6712 (***19.52%***)	0.0686	-0.1989	-0.3058	-0.0340	1.0396	0.0754
All	***3.4381 (100.00%)***	***0.2853 (8.30%)***	***-0.0015 (-0.04%)***	***-0.4113 (-11.96%)***	***-0.1290 (-3.75%)***	***2.1772 (63.33%)***	***0.9428 (27.42%)***
2000							
0-4	1.5692 (***30.94%***)	0.0602	-0.0101	-0.0004	-0.0029	0.5929	0.2415
5-14	0.1579 (***3.11%***)	0.0150	-0.0119	-0.0004	-0.0005	0.0229	0.1339
15-39	0.8959 (***17.67%***)	0.0398	0.1362	-0.0019	0.0115	0.0399	0.5574
40-64	1.1524 (***22.72%***)	0.0502	0.2556	-0.1071	0.1441	0.3323	0.3214
65+	1.2957 (***25.55%***)	0.0581	-0.1912	-0.2737	0.2667	0.9683	0.1187
All	***5.0710 (100.00%)***	***0.2232 (4.40%)***	***0.1786 (3.52%)***	***-0.3834 (-7.56%)***	***0.4190 (8.26%)***	***1.9562 (38.58%)***	***1.3729 (27.07%)***
2005							
0-4	0.6080 (***12.49%***)	0.0246	0.0094	0.0009	0.0032	0.1040	0.1384
5-14	0.1608 (***3.30%***)	0.0022	0.0156	-0.0011	0.0001	0.0078	0.1301
15-39	1.3377 (***27.48%***)	0.0217	0.2486	0.0238	0.0459	0.0219	0.7205
40-64	1.1632 (***23.90%***)	0.0161	0.4899	-0.0317	0.1557	0.1939	0.2539
65+	1.5979 (***32.83%***)	0.0172	0.1224	-0.1648	0.5893	0.7153	0.0761

All	***4.8677 (100.00%)***	***0.0818 (1.68%)***	***0.8859 (18.20%)***	***-0.1729 (-3.55%)***	***0.7941 (16.31%)***	***1.0429 (21.43%)***	***1.3190 (27.10%)***

TABLE 5

Contributions of Major Causes of Death to Gaps of Life Expectancy between Urban and Rural Areas of China (Years, Females)

Age Groups	All	Infect & Parasitic Diseases	Neoplasm	CHD	CVD	Respiratory Diseases	Injury & Poison
1990							
0-4	1.0431 (***34.58%***)	0.0741	-0.0191	0.0000	-0.0005	0.5259	0.3101
5-14	0.1163 (***3.86%***)	0.0351	-0.0191	0.0000	-0.0004	0.0319	0.0749
15-39	0.5106 (***16.93%***)	0.0546	-0.0189	0.0110	0.0017	0.0357	0.3354
40-64	0.6495 (***21.53%***)	0.0979	0.0750	-0.0582	-0.0605	0.3785	0.1661
65+	0.6973 (***23.11%***)	0.0689	-0.0750	-0.3141	0.0507	0.9381	0.0363
All	3.0168 (***100.00%***)	0.3306 (***10.96%***)	-0.0573 (***-1.90%***)	-0.3614 (***-11.98%***)	-0.0090 (***-0.30%***)	1.9101 (***63.32%***)	0.9228 (***30.59%***)
1995							
0-4	2.0959 (***42.35%***)	0.0420	-0.0131	0.0000	-0.0009	0.9300	0.3523
5-14	0.1281 (***2.59%***)	0.0190	-0.0179	0.0000	-0.0006	0.0269	0.1111
15-39	0.7171 (***14.49%***)	0.0617	0.0306	0.0076	0.0070	0.0543	0.4431
40-64	0.8704 (***17.59%***)	0.0813	0.1027	-0.0594	-0.0156	0.4014	0.2155
65+	1.1372 (***22.98%***)	0.0747	-0.0556	-0.3831	0.0449	1.3089	0.0763
All	4.9487 (***100.00%***)	0.2788 (***5.63%***)	0.0467 (***0.94%***)	-0.4349 (***-8.79%***)	0.0349 (***0.70%***)	2.7214 (***54.99%***)	1.1984 (***24.22%***)
2000							
0-4	2.3924 (***39.15%***)	0.0791	0.0031	-0.0010	-0.0005	0.8811	0.2984
5-14	0.1383 (***2.26%***)	0.0172	-0.0139	-0.0011	-0.0008	0.0230	0.0914
15-39	0.7635 (***12.50%***)	0.0325	0.0842	0.0072	0.0134	0.0394	0.4343
40-64	1.1224 (***18.37%***)	0.0548	0.1593	-0.0222	0.1664	0.3289	0.2394
65+	1.6935 (***27.72%***)	0.0562	-0.1385	-0.3446	0.2911	1.3523	0.0991
All	6.1101 (***100.00%***)	0.2397 (***3.92%***)	0.0942 (***1.54%***)	-0.3617 (***-5.92%***)	0.4697 (***7.69%***)	2.6248 (***42.96%***)	1.1626 (***19.03%***)
2005							
0-4	1.0675 (***20.82%***)	0.0263	0.0260	-0.0001	0.0103	0.1672	0.1758
5-14	0.1008 (***1.97%***)	0.0046	0.0051	0.0006	0.0030	0.0073	0.0595
15-39	0.7803 (***15.22%***)	0.0117	0.1654	0.0149	0.0294	0.0231	0.2906
40-64	0.9374 (***18.28%***)	0.0186	0.2651	0.0011	0.1658	0.2075	0.1422
65+	2.2414 (***43.71%***)	0.0199	0.1522	-0.2084	0.7314	1.1019	0.0780

All	5.1274 (***100.00%***)	0.0810 (***1.58%***)	0.6138 (***11.97%***)	-0.1920 (***-3.74%***)	0.9399 (***18.33%***)	1.5069 (***29.39%***)	0.7461 (***14.55%***)

However, the impact of CHD, CVD and neoplasm on the disparity of life expectancy from 1990 to 2005 showed a different pattern. Due to the higher mortality of citizens in 1990, CHD, CVD and neoplasm reduced the gaps by 17.56%, 13.03%, and 5.38%, respectively, in males. Subsequently, due to the unfavorable mortality trend in rural areas, the contributions of CVD and neoplasm to the gaps was reversed and the impact was gradually strengthened from 2000, accounting for 16.31% and 18.20% to the gaps in 2005. In addition, although the CHD mortality was higher in the urban areas during the study period, the offset effect on the gaps in males was decreased only by 3.55% in 2005. Similar results were also observed in females. As the impact of CVD and neoplasm on the disparity in life expectancy, the contribution of middle aged and elderly population increased from 37.41% to 56.73% in males and 44.64% to 61.99% in females.

Furthermore, the mortality rates of neoplasm and CVD have increased gradually in the rural population since 1990 and were higher than in the urban population, especially in those aged 15-39 years since 2000. Although the mortality rate of CHD was higher in the urban population aged 40 years or above than in the rural population, disparity in mortality was obviously decreased from 1990 to 2005. The mortality of CHD was higher in rural young adults aged 15-39 years than in adults of the same age group.

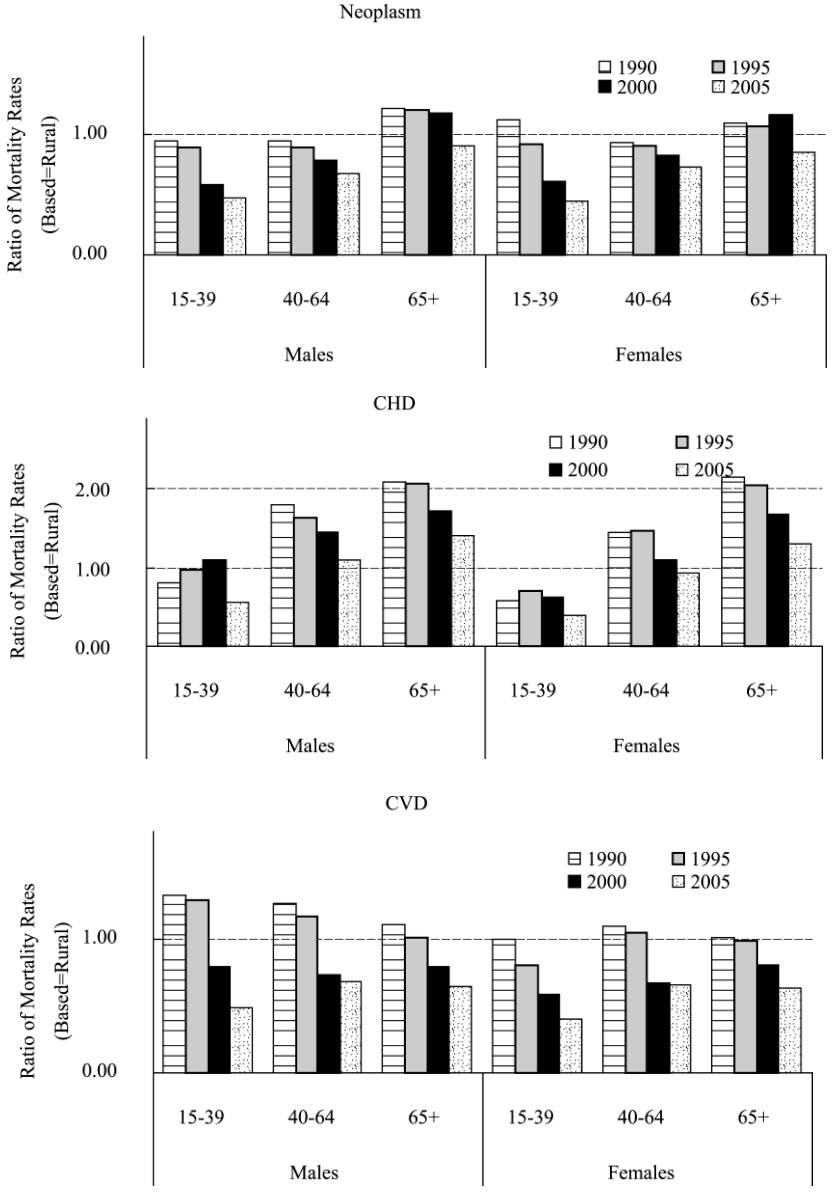

FIG. 2. Mortality ratio of urban to rural population aged 15 years or above for neoplasm, CHD, and CVD in 1990, 1995, and 2005.

DISCUSSION

China has made great progress in her overall development. In recent years, some researchers have turned their interest to the health improvement by focusing on the mortality level and trend in this country[12-13], as well as mortality patterns and regional variations[3,14]. Our study differs from previous ones in the two following aspects. First, in order to explore the roles that major causes of death played in mortality-related health we broadened our perspectives to inequality of life expectancy, not only just concerning on improvement. Second, we focused on the quantitative and systematic evaluation of the impact of major causes of death on the life expectancy changes in China based on the available data. The three key findings of our study are presented as follows.

Firstly, the major contributors to the gains of life expectancy from 1990 to 2005 in the urban are CVD, respiratory diseases and neoplasm. These are different from those in the rural, where respiratory diseases, infectious and parasitic diseases, as well as injury and poison compose the leading contributions. According to the epidemiological transition pattern[15], China's health challenge is shifted from diseases-related living conditions to diseases-related behavior and lifestyle. In our study, the urban and rural populations were at different stages of transitions, with rural areas lagging behind urban areas. Improvements of medical treatment and rehabilitation care in urban residents, such as more recommendations and applications of the guidelines for standardized treatment, safe and effective use of medicines, introduction of advanced surgical procedures, availability and accuracy of diagnostic or therapeutic equipments, help patients achieve better health and delay the age of death[16-17], leading to the most gains due to mortality decline of neoplasm and cardiovascular diseases in our study. Based on the data obtained from hospitals under the Ministry of Health of China, the case fatality rate of cardiovascular diseases decreased by nearly 37% in urban areas in 2006 compared to that in 1992[2]. The improvement of living conditions and implementation of immunization have played a most important role in the increase of life expectancy of the rural population. The data obtained from the Nationwide Health Services Survey in 2002[18] illustrate that rapid improvement has been made in water quality, sanitation, and immunization coverage in the past decade. The proportion of rural residents accessible to safe piped water increased from 22% in 1993 to 34% in 2003. The percentage of rural households without sanitary lavatory decreased from 95% in 1993 to 80% in 2003. Immunization for BCG, DPV, OPV, MV, and Hepatitis B covered 95.4%, 87.0%, 88.6%, 93.7%, and 76.7% of the rural population, respectively in 2003. A national chimney stove intervention program has been popularized in 75% of rural households since 1981, thus decreasing the exposure to a substantial pollution from stoves with solid materials as fuels[19]. All of these efforts can explain the reason why the mortality of diseases-related living conditions has decreased in the rural areas.

Secondly, although respiratory diseases, injury and poison and infectious diseases still constitute an important public health issue associated with the life expectancy changes, their influence was diminishing from 1990 to 2005. A substantial disparity in living environment and health care still exists between Chinese urban and rural areas. As disclosed by the National Health Services Survey in 2003, in the urban households only 13% lacked access to sanitary lavatory, nearly 96% were provided safe piped water and over 90% urban immunization coverage, and so on, so there is more room for progress in the rural areas[18]. Urban and rural disparity in mortality of injury and poison was mainly observed in children under the age of 5 years and in adults at the age of 15-39 years in our study. According to the data obtained from VR-MOH, injury due to drowning and suffocation is the leading cause of death in children, and suicide is the first or second leading cause of death in adults. Phillips *et al.*[20] reported that the suicides rate in China was 3 times higher in rural areas than in urban areas. The relative scarcity of health resources, expensive medical cost compared to their income, as well as low coverage of medical security become the obstacles in access to health service facing the farmers[18,21], which partly explained why less improvements of mortality in neoplasm and cardiovascular diseases are achieved by the rural population.

Thirdly, since the mortality rates of neoplasm and cardiovascular diseases, especially in adults at the age of 15-39 years, are higher in rural areas than in urban areas, their contribution to the disparity in life expectancy has increased since 1990, thus providing the up-to-date valuable evidence for the burden and impact of chronic diseases. Therefore, more efforts should be made to decrease the incidence of cardiovascular diseases and neoplasm in adults living in rural areas. Data obtained from the Health and Nutrition Survey in 2002 show that the Chinese populations have a relatively high exposure to risk factors[17]. Rural residents have a higher exposure risk to some factors, including high blood pressure, unhealthy diet, and environmental pollution, and so on. For example, the rural residents at the age of 18-44 years have a higher mean systolic blood

pressure than the urban residents[17]. Many decision makers always misunderstand that chronic diseases afflict only the affluent and the elderly. In fact, only 20% of chronic disease deaths occur in high income countries, while 80% occur in low and middle income countries where middle-aged adults are especially vulnerable and tend to develop disease at younger ages who suffer longer and die sooner than those in high income countries[4].

All of these findings in our study have shown that the leading causes of death have great impact on the mortality-related health in China, and have involved important public health implications. China is a developing country and always gives her priority to the reduction in infant and maternal mortality and control of infectious diseases as recommended by international agencies[22-23]. However, our results suggest that more attention should be paid to chronic diseases in middle-aged and elderly populations, especially in rural areas, which helps us to reap greatest benefits from the limited investment in health.

At present, the complete registration system is not available in China. Two available national systems of death reporting, VR-MOH and Disease Surveillance Point system (DSP), can provide valuable data on causes of death[24-25]. VR-MOH covers about 110 million people, half in urban areas and half in rural areas[25]. DSP covers 145 surveillance points with about 10 million people scattered in 31 provinces and autonomous regions or municipalities of China[25]. Some of surveillance points in DSP are overlapped with those in VR-MOH, especially in eastern and central areas[25]. Three types of medical evidence from medical records or files, including autopsy or biopsy, laboratory or radiology tests (clinical diagnosis) and inference after death, can be used in the diagnosis and classification of causes of death. In addition, persons who died of uncertain causes accounted for less than 5% of all deceased cases in either VR-MOH or DSP. We compared the crude mortality and distribution of dead persons by age groups, sex, cause of death and areas based on the available data, and found that the distribution is similar between VR-MOH and DSP (P>0.05), indicating that there is a similar structural mortality between these two systems. Therefore, we used the proportions of major causes of death obtained from VR-MOH as the reference values in our study. Because of the underreported deaths, especially in infants and children, the life expectancy calculated in our study using unadjusted data was higher than that in other studies. Gu *et al.*[3] used adjusted mortality rates to estimate the life expectancy of urban and rural populations of China in 1990 and 2000. Compared with their results, the difference in our study was about 0.50 years or less in 1990 and less than 0.30 years in 2000. Therefore, the influence of underreported deaths and their changes may not reverse the results. Because the implementation of ICD-10 for coding causes of death since 2002 has directly or indirectly influenced the data, the crude mortality rate obtained from VR-MOH in 2005 was by 5.37‰ lower than that obtained from the 1% sampling survey in the same year. However, the distribution of dead persons by age groups was not significantly different between VR-MOH and the 1% sampling survey in 2005 (P>0.05), and the proportions of causes of death in 2005 were similar to those in 2000 (P>0.05), suggesting that the coding changes could not influence our results. In addition, most surveillance points in both VR-MOH and DSP are located in more developed areas along the eastern coast, and few in less-developed rural areas of West China[24], indicating that the impacts of major causes of death on the changes in life expectancy in our study cannot completely represent the whole picture in China.

In summary, neoplasm and cardiovascular diseases in middle-aged and elderly populations are the main factors related with health improvement in urban and rural areas of China. More attention should be paid to cardiovascular diseases and neoplasm among rural residents. At present, the mortality reduction is mainly due to the improved sanitation, better water quality, immunization and medical treatment. Further efforts should be made to reduce population-based risk factors by promoting healthy behavior and lifestyle, such as adopting a healthier diet and activity patterns, maintaining a healthy weight, and quitting smoking, and to maximize appropriate therapies for all patients in need. Effective programs for the prevention of injury and poison in rural areas should be developed and implemented as soon as possible.

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