THE CHINESE ENVIRONMENTAL POLICY RESEARCH WORKING PAPER

Issue 10 Volume 3 No.4 December 2016

Chinese Academy for Environmental Planning
http://www.caep.org.cn

An Analysis of Disease Burden Attributable to Urban Air Pollution in the Context of Population Ageing in China from 2010 to 2030

YU Fang, MA Guoxia, XU Weipan, ZHANG Yanshen, WANG Jinnan

Forword »

Editor in Chief: Prof. WANG Jinnan



Since its opening-up and reform, China has been in the process of rapid economic development with its people enjoying an increasingly improved standard of life. Meanwhile accompanying this dramatic economic growth is the degradation of environment which has, to some extent, damaged the gains of the opening-up and reform and prevented the economy from a healthy and sustainable development. The Chinese government is increasingly aware of that without addressing the environmental issues it is facing now will jeopardize its long term goal of the great rejuvenation of the Chinese nation. Given the magnitude and complexity of the environmental issues in China, there is no easy way in addressing them and the solution to them entails an equal priority being given to environmental protection, ecological conservation and economic development or even higher than the latter by mainstreaming the former into the overall socio-economic decision-making process. As a matter of fact, China has been in the struggle against environmental pollution since the very beginning of its economic take-off and trying to explore a pathway that could help address China's environmental issues in the way most suitable to China's specific circumstances.

In recent years, especially since the 12th Five-Year Plan period, the enhanced measures including legislation, policy, regulatory and economic means have been taken by the Chinese government in dealing with environmental problems, of which environmental policies have played an important role in this regard. Corresponding to this situation and in meeting the demand of governments at different levels for environmental policy tools, the environmental policy research projects on topics of a wide range have been conducted by some Chinese environmental research institutions including the Chinese Academy for Environmental Planning (CAEP).

CAEP founded in 2001 is a research advisory body supporting governments in the development of key environmental planning, national environmental policies, and major environmental engineering projects. In the past more than 10 years, CAEP accomplished the development of the overall planning of national environmental protection for the 10th, 11th and 12th Five-Year Plan periods; water pollution prevention and control planning for key river basins; air pollution prevention and control planning for key regions; soil pollution prevention and control planning; and some regional environmental protection plans. In the same period of time, CAEP also actively engaged in research on such topics as green GDP, environmental taxation, emission trading, ecological compensation, green financing, etc. By so doing, CAEP has become an indispensable advisory body in the environmental decision-making in mainland China. According to *2013 Global Go To Think Tanks Report and Policy Advice* published by University of Pennsylvania, CAEP was ranked 31 in the field of environment in the world. Many of CAEP's research results and project outcomes regarding environmental policies have drawn great attention of decision makers and international institutions, and have been utilized to contribute to the formulation of national environmental policies concerned.

The Chinese Environmental Policy Research Working Paper (CEPRWP) is a new internal publication produced by CAEP for the purpose of facilitating the academic exchange with foreign colleagues in this field, in which the selected research papers on environmental policies from CAEP are set out on the irregular basis. It is expected that this publication will not only make CAEP's research results on environmental policies be known by foreign colleagues but also serve as a catalyst for creating opportunity of international cooperation in the field of environmental policies, and environmental economics in particular, with a view of both the academic research and practical policy needs.

Contents

An Analysis of Disease Burden Attributable to Urban Air Pollution in the Context of Population Ageing in China from 2010 to 2030

YU Fang , MA Guoxia , XU Weipan , ZHANG Yanshen , WANG Jinnan

Abstract:

Air pollution has a great impact on human health. Accelerated population ageing in China will aggravate disease burden attributable to air pollution. Making use of the predictive population data of different age groups in China from 2010 to 2030, and adopting the methodology of Environmental Burden of Disease (EBD), this Study calculates the disease burden of people in different scenarios of air pollution. Results show: 1) Population ageing has a great impact on disease burden attributable to air pollution. Affected by ageing, Average Potential Years of Life Lost in 2030 will be 20 years, 33% higher than 2010; premature deaths attributable to air pollution will be 558,000, up by 20.1% over 2010. 2) If air quality is not improved, with the dual impact from urbanization and ageing, premature deaths attributable to air pollution in cities will grow markedly. In 2020, premature deaths attributable to air pollution in Chinese cities will be 632,000, up by 36% over 2010; in 2030, the figure will be 845,000, up by 81.8% over 2010. 3) To contain the growth in air-pollution premature deaths in cities, China has to improve air quality substantially. If the air quality of all Chinese cities reaches Grade I (40μg/m^3), premature deaths in 2030 can be controlled at the 2010 level.

Key Words:

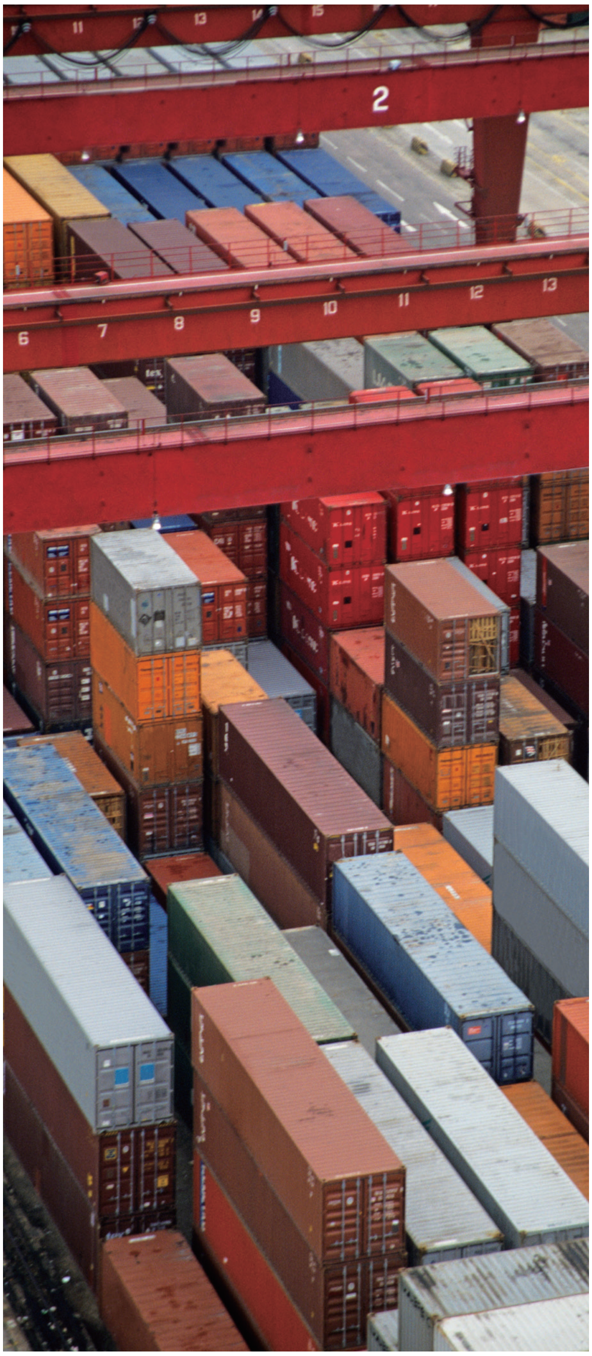
Population Ageing; Air Pollution; Disease Burden; Environment Health

1. Introduction

It has been a hot spot and focus in the environment policy making internationally to use the Environmental Burden of Disease (EBD) methodology to assess the impact of environment pollution on health[1]. The impact of air pollution on health in China has all along been a concern. International organizations such as the World Bank[2], World Health Organization[3] and Health Effects Institute of the USA assessed air pollution's damage to health in China. According to results as calculated by the Chinese Academy for Environmental Planning, premature deaths due to air pollution in China from 2004 to 2010 are between 350,000 and 500,000.

China has been a country with the world's largest aged population[6]. In 2011, the elderly dependency ratio for elderly people aged 65 or above was 13.08%. With the share of aged population in the total population continuously growing, China's population ageing will reach a peak in the coming 20 to 40 years in. Most studies on China's population ageing focus on its evolution process, characteristics, existing problems and countermeasures, and analyze the impact of ageing on the economy, supply of labor and consumption. Being vulnerable and susceptible, the elderly population are prone to impact from outside. With the aged population growing up, the disease burden caused by air pollution will be increased inevitably. If the air quality is not improved, premature deaths due to air pollution in China will be on the rise.

Using 2010 as the base year, this study calculates the years of life expectancy lost from 2010 to 2030 by predicting the population and deaths of different age groups. Air-pollution-caused premature deaths and Average Potential Years of Life Lost (PYLL) across different scenarios are calculated, and the air-pollution-caused disease burden in the context of population ageing is also analyzed.



2. METHODOLOGY AND DATE SOURCES

2.1 Average Potential Years of Life Lost

Potential Years of Life Lost (PYLL) represents the sum of differences between the life expectancy of a sample population with a certain disease and their actual life span without the impact of that disease. It is, therefore, the loss of life expectancy caused by premature death or a measure of premature mortality. Based on the expected life span, it calculates the potential years of life lost caused by death at different ages. And Average Potential Years of Life Lost (APYLL) can be calculated by using the PYLL and actual deaths. The APYLL of premature death attributable to air pollution is calculated based on the difference between the actual PYLL (with air pollution being considered) and the PYLL without air pollution being considered.

$$APYLL = (\sum_{x=1}^{19} e_x * nd_x) / \sum_{x=1}^{19} nd_x$$

$$PYLL_a = \sum_{x=1}^{19} e_x * d_x - \sum_{x=1}^{19} e_{ax} * (d_x - d_{ax})$$

In the formula, APYLL means Average Potential Years of Life Lost, x means age group. There are 19 age groups in China. e_x means the actual life expectancy of age group x. d_x measures actual deaths in a certain age group. $PYLL_a$ represents the average potential years of life lost due to air pollution. e_{ax} is the life expectancy of age group x where there is no air pollution. d_{ax} is the number of deaths where there is no air pollution.

Being a key element in measuring the above indicators, life expectancy can be calculated via the life table. Life table is a table which is based on the mortality rate of different age groups of a certain population. For a certain generation of people (100,000 persons) who are born at the same time and die at different ages, the life table can be used to calculate the 'probability of death', 'number of death' and 'survivorship' of people from a certain age. As the life table is developed based on the mortality rate of different age groups, indicators in the table is not limited by the age mix of the population. The abridged life table in 2010 is based on the sixth National Population Census (Table 1). Table 2 shows the predictive data of population and mortality in different age groups in 2020 and 2030.

The abridged life table (Table 1) is prepared as follows:

(1) Age: age intervals x to x+n, where x=0, 1, 5, 85, and above, and n is the width of the age interval in years.

(2) nMx: age-specific death rates calculated from information on deaths among persons aged x to x+n during a given year and the population aged x to x+n at the mid-point of the same year. $nMx=nDx/nPx$.

(3) nQx: probability of death refers to the probability of dying between exact ages x and x+n. For the 0~ years age group, the probability of death-Q_0 can be replaced with the infant mortality rate. For other groups, we follow the formula $nQx+2 \times n \times nMx/(2+nMx)$, in which n means the age interval of different age groups. For the last age group, the probability of death is 1.

(4) lx: number of people alive at exact

age x among a hypothetical birth cohort of 100000. l_0=10000, $d_0=l_0\times Q_0$, $l1=l_0-d_0$, $ndx=lx\times nQx$, $lx+n=lx-nd$.

(5)nLx: total number of person-years lived between exact ages x and x+n. $l_0=l_1+0.15\times d_0$ for the 0 year age group (0.15 is the empirical coefficient for China), $nLx=n\times(lx+lx+n)/2$, $Lw=lw/mw$ for the last age group: Where, lw is the number of survivors in the last group and mw is the mortality rate of the last group in the death statistics.

(6) Tx: total number of person-years lived after age x: Tx=Tx+n+nLx.

(7) e_x: expected average number of years of life left for a person age x: $e_x=Tx/lx$.

Table 1: Abridged Life Table of Urban Citizens for the Sixth National Population Census of 2010

age X	population nPx	death nDx	death rate nMx	Probability of death nQx	alive lx	life table death ndx	Person-years lived nLx	Total number of person-years lived Tx	life expectancy e_i
0-	5375279	15904	0.0030	0.0030	100000	296	99749	8078756	80.79
1-	25561191	9697	0.0004	0.0015	99704	151	398514	7979008	80.03
5-	30565659	5300	0.0002	0.0009	99553	86	497549	7580494	76.15
10-	32807526	5964	0.0002	0.0009	99467	90	497107	7082945	71.21
15-	53589992	10936	0.0002	0.0010	99376	101	496628	6585837	66.27
20-	71058518	18001	0.0003	0.0013	99275	126	496061	6089209	61.34
25-	57679956	18474	0.0003	0.0016	99149	159	495350	5593149	56.41
30-	56010957	25046	0.0004	0.0022	98991	221	494401	5097799	51.50
35-	65025365	45330	0.0007	0.0035	98770	344	492989	4603398	46.61
40-	63786496	70321	0.0011	0.0055	98426	541	490777	4110410	41.76
45-	53629541	94613	0.0018	0.0088	97885	860	487275	3619633	36.98
50-	39186388	123132	0.0031	0.0156	97025	1512	481345	3132358	32.28
55-	37437535	170428	0.0046	0.0225	95513	2150	472190	2651013	27.76
60-	26036917	195791	0.0075	0.0369	93363	3446	458202	2178823	23.34
65-	17910329	234251	0.0131	0.0633	89918	5694	435353	1720621	19.14
70-	14777260	347803	0.0235	0.1111	84224	9361	397716	1285269	15.26
75-	10531503	416652	0.0396	0.1800	74863	13476	340624	887553	11.86
80-	5762828	386359	0.0670	0.2871	61387	17624	262874	546929	8.91
85-	2584543	398188	0.1541	1.0000	43763	43763	284054	284054	6.49

Note: The data is based on the deaths in the sixth national population census of 2010 according to age and gender.

Table 2 China's Total Population and Urban Population of Different Age Groups in 2020 and 2030 (Unit: Person)

	2020			2020		
Age Group	Total Population	Urban Population	Mortality Rate	Total Population	Urban Population	Mortality Rate
0	14412861	8373289	3.8	11150859	7730026	2.5
1-4	68419675	39749064	0.5	52934537	36695413	0.3
5-9	80530944	46785221	0.3	74469234	51623749	0.2
10-14	77715286	45149438	0.3	82530536	57212025	0.2
15-19	74503800	43283694	0.5	79999508	55457460	0.4
20-24	85502189	49673314	0.7	76324414	52909802	0.6
25-29	101347754	58878946	0.9	72573462	50309557	0.7
30-34	126191430	73312117	1.1	83730899	58044144	1.0
35-39	99479184	57793382	1.4	99844683	69214582	1.3
40-44	92484264	53729617	1.8	124438640	86263666	1.6
45-49	114227816	66361741	2.8	97583072	67646782	2.4
50-54	118770840	69001054	3.7	89881427	62307828	3.0
55-59	95420349	55435363	5.6	109201237	75700755	4.5
60-64	72964803	42389599	9.3	110488930	76593413	7.6
65-69	69956093	40641661	15.8	85090046	58986335	12.9
70-74	45440868	26399306	26.9	60043953	41623820	21.8
75-79	27920363	16220602	45.9	51144123	35454257	38.9
80-84	17538651	10189247	73.5	26696771	18506803	62.8
85-89	8401852	4881136	115.5	11113122	7703866	102.3
90-94	2391229	1389207	183.5	3803163	2636438	163.9
95-99	370526	215261	217.8	778436	539629	185.7
100+	25200	14640	274.5	72198	50049	20.4

Data Source: Total Population and Urban Population are based on data on the website of **US Census Bureau** http://www.census.gov/population/international/data/idb/informationGateway.php

Mortality rate of different age groups are based on research results by Meng Lingguo and other researchers [23].

2.2 Premature Mortality due to Air Pollution

The calculation of premature deaths due to air pollution depend on such indicators as air pollutants, the health threshold value of air pollutants, the health results of air pollutants and the exposure-response relations. A certain region's health damage background value is first calculated according to the region's air pollution level, health damage results and exposure-response value. The damage of air pollution against health is the value after the health damage background value is deducted. This study takes PM_{10} as the air pollutant. The methodology for verifying the above mentioned indicators can be referenced in the already published research results[15].

Premature Deaths Attributable to Air Pollution as follow:

$$P_{ed} = 10^{-5} \cdot ((RR - 1)/RR)\, f_p P_e$$

In the formula, P_{ed} refers to the number of all-cause premature deaths at the current air pollution level (in ten thousand persons); f_p refers to the all-cause mortality rate at the current air pollution level (1/100,000). The 2010 data is from China Health Statistical Yearbook (2011). The 2020 and 2030 data is calculated from the above mentioned age-group population data and mortality data. f_t refers to the all-cause mortality rate at the clean density level (1/100,000); P_e refers to urban exposed populations (in ten thousand persons). The 2010 data is from China City Statistical Yearbook and the 2020 and 2030 urban population prediction is from ADB's Study of China's Water Sector; RR refers to the relative risk ratio of all-cause deaths attributable to air pollution.

2.3 Scenario Analysis

A premature death attributable to air pollution is a major indicator measuring air pollution disease burden. Premature deaths are linked to such factors as the exposed population, all-cause actual mortality rate, air quality and APYLL. As a result of population ageing, China's APYLL and all-cause actual mortality rate are on the rise. Meanwhile, China's urbanization is irreversible and the urban population will be increased at a faster pace. If the air quality fails to be improved, China's air-pollution-caused disease burden will certainly grow dramatically. In consideration of the above, this Study analyzes the impact of population ageing on the air-pollution-caused disease burden in China by looking at three scenarios, ie, the baseline scenario in which air quality is not improved, high and low scenarios in which air quality is improved to different degrees.

Baseline Scenario: Air quality in 2020 and 2030 are not improved. The average PM_{10} concentration stays at the 2010 level.

High Scenario: In 2020, cities which have already reached National Grade II standard in terms of average PM_{10} concentration stay at the current level. The average PM_{10} concentration in cities which have not reached National Grade II standard reach the standard of 70μg/m^3. In 2020, all regions reach the National Grade I standard, ie 40μg/m^3.

Low Scenario: In 2020, the targets set in the Air Pollution Prevention and Control Action Plan in relation to the average PM_{10} concentration are reached, ie, as compared with that in 2012, the PM_{10} concentration in cities at or above the prefectural level goes down by 10%; the PM_{10} concentration in the Beijing-Tianjin-Hebei Area, Yangtz-River Delta and Pearl-River Delta goes down by 25%, 20% and 15% respectively. The PM_{10} concentration in Beijing is controlled at around 60 μg/m^3. In 2030, the PM_{10} concentration in cities at or above the prefectural level is close to the 2010 level of the USA and the annual PM_{10} concentration in all regions is 50 μg/m^3.

2.4 Date Sources

The Study includes information obtained from National Atmospheric Environment Monitoring Date (2010) for cities at or above the county level, which is collected by the China National Environmental Monitoring Center; China Health Statistics Yearbook (2010) ; National Health Service Survey 2008: the 4th Household Health Interview Survey Analysis Report; China Statistical Yearbook (2011) and China City Statistical Yearbook (2011). Some key parameters are cited from Guideline for Chinese Environmental and Economic Accounting. Urban population predictive data, age-group population data, age-group mortality data are from relevant references.

3. RESULTS

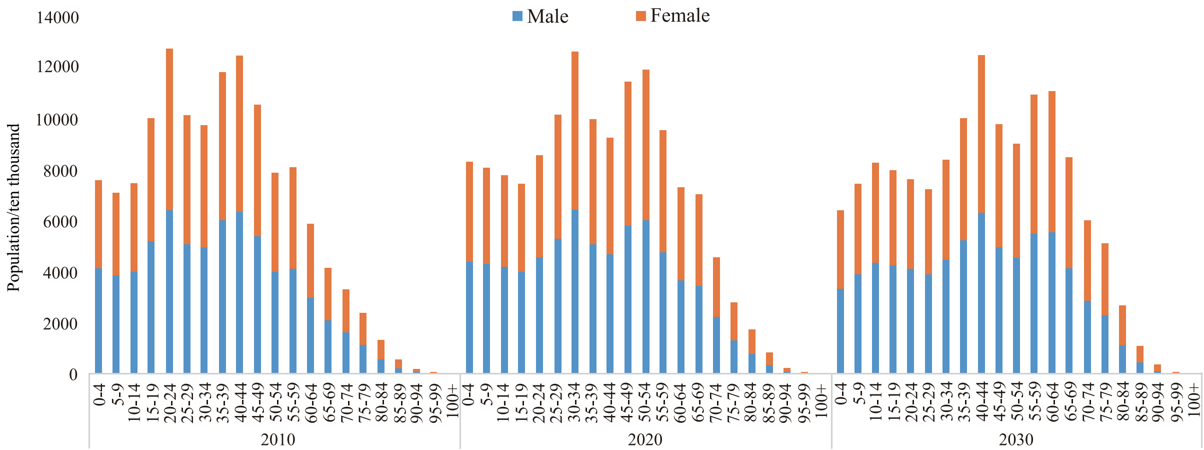
3.1 How China's Population Ageing Evolves

As a manifestation of social progress and improved livelihood, population ageing represents an important mark of a country's modernization. According to WHO standards, a region will enter the era of population ageing when people aged over 60 account for 10% of the total population, or when people aged over 65 account for 7% of the total population. When people aged over 65 account for 14% of the total population, the region will enter the era of 'super' population ageing. In October 1999, China completed its transition from a country where adults feature prominently to a country where the elderly feature prominently. China is the world's only country where the aged population is over 100 million and growing at a fast rate of over 3% annually. China will be in a process of rapid ageing between 2010 and 2020 and in a process of accelerated ageing between 2020 and 2030. In the meantime, the population aged over 80 will also be growing markedly.

According to data obtained from the Sixth National Population Census, the proportion of the population aged over 60 among the total population was 13.26%; the proportion of the population aged over 65 was 8.87%; the proportion of the population aged over 80 was 1.57%. According to the predictive data from the US Census Bureau, in 2020, China's total population is 1.394 billion, and the proportion of the population aged over 60 among the total population will be 17.57%; the proportion of the population aged over 65 will be 12.34%; the proportion of the population aged over 80 will be 2.06%. In 2030, China will enter an era of 'super' population ageing when its total population will be increased to 1.404 billion with the proportion of the population aged over 60 being 24.88% of the total population; the proportion of the population aged over 65 being 17.01% and the proportion of the population aged over 80 being 3.02% (Fig 1).

Due to regional disparity, population ageing also varies significantly across regions. Different from developed countries which are featured by 'getting rich first and getting old latter', China, in terms of population ageing, is featured by 'getting old before getting rich' or 'getting old though not getting rich'. The impact of ageing can be found in labor supply, savings and economic growth, which is reflected, among others, as low productivity and shortage of innovation. In addition, with a large proportion of the aged population being disabled people, China is faced with an increasing demand from the elderly for Medicare. Diseases commonly seen among the Chinese aged population include malignant tumor, cerebrovascular disease, heart disease, diabetes, high blood pressure and respiratory disease, which contribute to 83.4% of total deaths of elderly people aged over 65. The direct economic burden caused by these 6 diseases in 2003 was as high as 34 billion RMB Yuan. Being a vulnerable group which is susceptible to various acute and chronic diseases, the elderly people face increasing disease burden year on year as they get old. The burden for diseases caused by air pollution is the most remarkable.

Figure 1 China's Age and Gender Structure from 2010 to 2030



3.2 Impact of Ageing on Disease Burden Caused by Air Pollution in China

The burden of diseases caused by air pollution in this Study is mainly measured by premature deaths attributable to air pollution, which in turn are mainly affected by the exposed population, all-cause actual mortality rate, air quality and the APYLL. Population ageing gives rise to changes in all-cause actual mortality rate and the APYLL. From 2010 to 2030, if the urban population and air quality do not change, change in the disease burden attributable to air pollution will be mainly attributed to ageing.

The Study aims to analyze ageing's impact on air-pollution-caused disease burden on the assumption that air quality and urban population do not change. As shown by research results, the APYLL in China tends to rise as the population ages. In 2010, China's APYLL is 15 years with an all-cause mortality rate of 630.3/100,000 in urban areas; in 2020, the APYLL is expected to rise to 21 years with an all-cause mortality rate of 655.6/100,000; in 2030, the APYLL is expected to be 20 years with an all-cause mortality rate of 724.4/100,000. As a result of growth in the all-cause mortality rate and APYLL, premature deaths due to air pollution will be rising. In 2010, China's premature death due to air pollution was 465,000. In 2020, the figure will go up to 493,000, up by 6.1% over that of 2010. In 2030, the figure will rise further to 558,000, up by 20.1% over that of 2010.

As China is experiencing rapid urbanization with an annual urbanization rate of around 1%, the number of people being exposed to air pollution grows dramatically. This study looks at the disease burden caused by growth in urban population from 2020 to 2030 with the presumption that the population ageing and air pollution density remain unchanged. In 2020 when the urban population rises, if China's air quality does not improve, the premature deaths due to air pollution will go up to be 608,000, and 717,000 in 2030, which are up by 30.8% and 54.4% respectively over 2010.

China is moving from the stage of rapid ageing onto the stage of accelerated ageing, population ageing's impact on air-pollution-caused disease burden will be further aggravated. If the air quality fails to be improved, and as population ages and urbanization accelerates, there will be a remarkable increase in air-pollution-caused disease burden as a result of population ageing.

3.3 Prediction of Air-pollution Disease Burden in Different Scenarios from 2010 to 2030

In the baseline scenario, if the air quality is not improved and stays at the 2010 level, driven by both urbanization and ageing, the premature deaths attributable to air pollution will grow markedly. In 2020, premature deaths attributable to air pollution in Chinese cities will be 632,000, up by 36% over 2010; in 2030, the figure will be 845,000, up by 81.8% over 2010. If the air quality is improved but with a small margin, in the low improvement scenario, the premature deaths attributable to air pollution will continue to rise. The premature deaths attributable to air pollution in 2020 and 2030 will be 576,000 and 616,000 respectively, growing by 23.9% and 32.8% respectively over that of 2010. In the high improvement scenario, the air-pollution premature deaths drop after rising. Premature deaths attributable to air pollution in 2020 and 2030 will be 563,000 and 503,000 respectively, growing by 21% and 8.2% respectively over that of 2010. To contain the growth in air-pollution premature deaths in cities, China has to improve air quality substantially. If the air quality of all Chinese cities reaches Grade I (40μg/m^3), premature deaths in 2030 can be controlled at the 2010 level.

Further scenarios are developed to calculate the APYLL attributable to air pollution on the basis that the APYLL attributable to air pollution is 0.66 year. In the baseline scenario, the APYLL in 2020 and 2030 will go up to 1.69 and 1.68 years respectively, up by 1 year over that of 2010. In the low improvement scenario, the APYLL in 2020 and 2030 will be 1.52 and 1.18 years respectively, up by 0.9 and 0.5 years over that of 2010. In the high improvement scenario, the APYLL in 2020 and 2030 will be 1.48 and 0.95 years, up by 0.8 and 0.3 years over that of 2010.

Along with intensified industrial transfer and rapidly-growing urban population in the West, premature deaths attributable to air pollution in the West grow faster that in the East. In the baseline scenario, the premature deaths of the East grow by 67.1% in 2030 over 2010. The premature deaths in the Beijing-Tianjin-Hebei Area, Yangtz-River Delta and Pearl-River Delta, which are eastern regions of high population density, go up by 89.7%, 87.4% and 69.3% over 2010. The disease burden is greater in area of population aggregation where air quality is not improved. In 2030, premature deaths in the West increase by 103.1% as compared with 2010. Premature deaths due to air pollution in the following areas increase by over 100%: Guizhou(134.2%), Yunnan(125.5%),Xinjiang(117.4%), Gansu(114.9%), Sichuan(104.8%)and Guangxi(101.4%) (Table 3). In the low improvement scenario, premature deaths in the East increase by 22.7% as compared with 2010, premature deaths in the West increase by 51.8% as compared with 2010. In the high improvement scenario, premature deaths in the East of 2030 can be controlled at the 2010 level, premature deaths in the West increase by 22% as compared with 2010.

Table 3: Premature deaths in different scenarios in China (Unit: person)

region	baseline scenario			low improvement scenario			high improvement scenario		
	2010	2020	2030	2010	2020	2030	2010	2020	2030
Beijing	14490	19353	26046	14490	13066	15329	14490	14470	12540
Tianjin	7900	11636	16744	7900	9900	11019	7900	9728	9014
Hebei	22376	30499	42195	22376	25519	30119	22376	27465	24639
Shanxi	11490	15347	20122	11490	14383	15087	11490	14406	12342
Inner Mongolia	9014	11583	14463	9014	10835	11136	9014	10696	9110
Shanxi	19008	22438	27532	19008	21083	19920	19008	20174	16296
Jilin	9825	12816	16785	9825	12006	12659	9825	11971	10356
Heilongjiang	13595	17132	21882	13595	16020	16923	13595	15671	13844
Shanghai	14207	16948	22133	14207	14745	16199	14207	15758	13252
Jiangsu	36115	46223	58018	36115	40835	38494	36115	38924	31491
Zhejiang	24032	31261	38894	24032	27356	27466	24032	27856	22469
Anhui	18303	26130	35944	18303	24592	25408	18303	23141	20785
Fujian	13181	17506	22450	13181	16313	18146	13181	16996	14844
Jiangxi	12082	16864	23614	12082	15702	19278	12082	16346	15771
Shandong	35589	45383	60317	35589	42839	40825	35589	38301	33398
Henan	28713	44364	62848	28713	42035	40103	28713	35963	32807
Hubei	21422	28855	37719	21422	27250	25335	21422	24621	20725
Hunan	19699	27939	38248	19699	26234	27945	19699	25745	22861
Guangdong	37838	48142	60920	37838	42297	56219	37838	48051	45990
Guangxi	10434	15390	21017	10434	14223	18765	10434	15390	15351
Hainan	1628	2224	3005	1628	1966	3005	1628	2224	3290
Chongqing	12123	17955	23958	12123	17012	15291	12123	14558	12509
Sichuan	21628	31764	44300	21628	29747	33574	21628	28955	27466
Guizhou	7881	12548	18461	7881	11756	13907	7881	11457	11377
Yunnan	9185	14254	20710	9185	13192	18202	9185	13698	14890
Tibet	333	690	1096	333	629	1134	333	690	928
Shanxi	13154	18286	25107	13154	17298	16437	13154	14888	13447
Gansu	7259	11026	15600	7259	10445	9991	7259	8887	8173
Qinghai	2187	2953	3962	2187	2814	2306	2187	2184	1887
Ningxia	2233	3051	4067	2233	2878	2784	2233	2627	2277
Xinjiang	7713	11393	16765	7713	10823	13040	7713	10823	8397
Total	464636	631953	844923	464636	575793	616044	464636	562663	502525

4. CONCLUSIONS

1) As one of fastest ageing countries, China is faced with problems of 'getting old before getting rich' or 'getting old though not getting rich'. Though being an inevitable result of social development and progress, population ageing is accompanied by a host of social problems such as low productivity, innovation shortage and increasing disease burden.

2) Population ageing has a severe impact on disease burden attributable to air pollution. Affected by ageing, the APPLY in 2030 will be 20 years, 33% higher than 2010; premature deaths will be 558,000, up by 20.1% over 2010.

3) If the air quality is not improved, driven by both urbanization and ageing, premature deaths attributable to air pollution in cities will grow markedly. In 2020, premature deaths attributable to air pollution in Chinese cities will be 632,000, up by 36% over 2010; in 2030, the figure will be 845,000, up by 81.8% over 2010.

4) To contain the growth in air-pollution premature deaths in cities, China has to improve air quality substantially. If the air quality of all Chinese cities reaches Grade I ($40\mu g/m^3$), premature deaths in 2030 can be controlled at the 2010 level.

REFERENCES

1 Yu F, Ma G X, Zhang Y S, Cao D, Gao F, Wang J N. Several issues on health impact assessment of air pollution in China. Nat Med J China, 2013, 93(34): 2695-2698 (in Chinese)

2 World Bank. Cost of pollution in China: economic estimates of physical damages. Washington D.C. 2007.

3 Ostro B. Outdoor air pollution: assessing the environmental burden of disease at national and local levels. Geneva, World Health Organization (WHO Environmental Burden of Disease Series), No.5, 2004

4 Yang G H, Wang Y, Zeng Y X, Gao G F, Liang X F, Zhou M G,Wan X, Yu S C, Jiang Y H, Naghavi M, Vos T, Wang H D, Lopez A D, Murray C J L. Rapid health transition in China, 1990–2010:findings from the Global Burden of Disease Study 2010. Lancet, 2013, 381(9882): 1987–2015

5 Chen Z, Wang J N, Ma G X, Zhang Y S. China tackles the health effects of air pollution. Lancet, 2013(382):1959-1960

6 Zhang K D, Guo P. The blue book of the aging population and the condition of the elderly in China. China social press, 2010

7 Wang Z Z, Sun T S, Li G P. Regional Differences and Evolutions of Population Aging in China. Population Research, 2013, 37 (1) : 66-77

8 Ma Y T. The Increasing Demographic Dividend: The Driving Force of China's Leaping Development in the 21th Century. Chinese Journal of Population Science, 2007(1): 2-10

9 Office of the National Committee on Aging. A forecast of the development trend of China's population aging.2006

10 Cai F, Wang M Y. Labor Shortage in an Aging but not Affluent Society. China Opening Journal, 2006 (1) :31-39

11 Fang X C, Xie X, Huang Z M. Population Aging and Economic Growth in China. Shanghai Journal of Economics, 2014(12):90-96

12 Wang Y. Spatial econometric analysis of the impact of China's population aging on economic growth. Social Science Research, 2015 (5) : 73-78

13 Sui Z, Zhou X M. The impact of labor supply on China's economic growth under the background of population aging.Contemporary Economic Research, 2014 (3) : 33-37

14 Sun L, Wu S P. An empirical study on the impact of China's population aging on the consumption of residents. Statistical observation, 2015 (9) : 98-101

15 Ma G X, Wang J N, Yu F, Guo X M, Zhang Y S, Li C. Assessing the premature death due to ambient particulate matter in China's urban areas from 2004 to 2013. Front. Environ. Sci. Eng., 2016, 10(5) : 1-10

16 Mu G Z, Zhang T. The development trend of aging population in China and its strategic response. Journal of Huazhong Normal University(Humanities and Social Sciences), 2011(50) 5:29-36

17 Liu J F, Chen Z, Yang F, et al. The present situation and Countermeasures of chronic diseases in the elderly in China. China &Foreign Medical Treatment, 2014 (23) :194-198

Chinese Academy for Environmental Planning

8 Dayangfang, BeiYuan Road, Chaoyang District, Beijing 100012, China

Editor in chief: Prof. WANG Jinnan

Vice President, Chinese Academy for Environmental Planning

Contact person: Ms. YANG Xiaolan

Tel: 86-10-84916891

Fax: 86-10-84918581

E-mail: yangxl@caep.org.cn

Web: www.caep.org.cn