PRESS RELEASE

EDITOR'S CHOICE

Economic costs attributable to smoking in China: update and an 8-year comparison, 2000–2008

Lian Yang,[1,2] Hai-Yen Sung,[3] Zhengzhong Mao,[1] Teh-wei Hu,[4] Keqin Rao[5]

[1]Department of Health Economics, Huaxi School of Public Health, University of Sichuan, Chengdu, China
[2]Department of Health Economics, School of Public Health and Administration, Chengdu University of Traditional Chinese Medicine, Chengdu, China
[3]Institute for Health & Ageing, University of California, San Francisco, California, USA
[4]School of Public Health, University of California, Berkeley, California, USA
[5]Centre of Health Statistics and Information, Ministry of Health, Beijing, China

Correspondence to
Keqin Rao, Centre of Health Statistics and Information, Ministry of Health of the People's Republic of China, 1 Xi Zhi Men Wai Nan Road, Beijing 100044, China; raokq@moh.gov.cn

Received 24 November 2010
Accepted 18 December 2010
Published Online First 21 February 2011

ABSTRACT

Objective To estimate the health-related economic costs attributable to smoking in China for persons aged 35 and older in 2003 and in 2008 and to compare these costs with the respective results from 2000.

Methods A prevalence-based, disease-specific approach was used to estimate smoking-attributable direct and indirect economic costs. The primary data source was the 2003 and 2008 China National Health Services Survey, which contains individual participant's smoking status, healthcare use and expenditures.

Results The total economic cost of smoking in China amounted to $17.1 billion in 2003 and $28.9 billion in 2008 (both measured in 2008 constant US$). Direct smoking-attributable healthcare costs in 2003 and 2008 were $4.2 billion and $6.2 billion, respectively. Indirect economic costs in 2003 and 2008 were $12.9 billion and $22.7 billion, respectively. Compared to 2000, the direct costs of smoking rose by 72% in 2003 and 154% in 2008, while the indirect costs of smoking rose by 170% in 2003 and 376% in 2008.

Conclusions The economic burden of cigarette smoking has increased substantially in China during the past decade and is expected to continue to increase as the national economy and the price of healthcare services grow. Stronger intervention measures against smoking should be taken without delay to reduce the health and financial losses caused by smoking.

INTRODUCTION

With 301 million current smokers in 2010,[1] China is the largest consumer of tobacco in the world. In 2010, 52.9% of Chinese men and 2.4% of women were current smokers. Despite numerous studies demonstrating that tobacco is harmful for health[2–5] and evidence showing that the overall mortality of smokers in China is significantly higher than that of never smokers,[6] most Chinese citizens still lack understanding of the harmful effects of smoking. In 2010, only 23.2% of Chinese adults believed smoking causes stroke, heart attack and lung cancer, and only 16.1% of current smokers planned to or were thinking about quitting in the next 12 months.[1]

At the same time, China is the world's largest producer of tobacco. All cigarettes are produced by the state-owned tobacco monopoly company, and about 7.0% of China's central government revenue was generated from tobacco profit and taxes.[7] Because of the economic interests of the tobacco industry, Chinese policymakers are unwilling to restrict promotion of tobacco products and to implement stricter legislation to protect non-smokers. To raise the general Chinese population's awareness of the dangers of smoking and to increase the government's incentive to implement the promises of the ratified WHO's Framework Convention on Tobacco Control, it is important to transform the data on the health effects of smoking into monetary values of financial losses to the society.

There is a paucity of national studies estimating the economic costs of smoking in China. Using a medical cost accounting method to calculate disease-specific medical costs, Chen *et al*[8] estimated the total medical costs attributable to smoking in 1988 in China at ¥2.3 billion (US$0.28 billion using the exchange rate of ¥8.2784 to US$1). Jin *et al*[9] estimated the total economic burden of smoking in China in 1989 at ¥27.1 billion ($3.27 billion using the exchange rate of ¥8.2784 to US$1), including ¥6.9 billion ($0.83 billion) of direct medical costs and ¥20.1 billion ($2.43 billion) of indirect morbidity and mortality costs. Sung *et al*[10] estimated the economic costs of smoking in China in 2000 at $5.0 billion (based on the exchange rate of ¥8.2784 to US$1), of which $1.7 billion were direct healthcare costs of smoking and $3.3 billion were indirect morbidity and mortality costs. These three studies of the costs of smoking in China were conducted more than 10 years ago. Due to China's economic growth and the introduction of high-tech medical equipment, wage rates and healthcare expenditures in China have increased substantially during the last decade. Therefore, the economic burden of smoking in China is very likely to have increased dramatically as well. It is important to examine the trend of smoking-attributable costs during the last decade.

The objective of this paper was to provide the latest estimates for direct and indirect costs of smoking in China by using data from the third and fourth waves of the China National Health Services Survey (NHSS) conducted in 2003 and 2008 and to compare these cost estimates with the respective 2000 estimates from the previous study by Sung *et al*.[10]

METHODS

We divided the economic costs of smoking into two components: direct costs and indirect costs. Direct costs include all healthcare expenditures for treating smoking-related diseases. Indirect costs include expenses for transportation, nutritious supplemental food and caregivers during inpatient hospitalisations and outpatient visits due to treating smoking-related diseases, the value of lost productivity caused by smoking-related illness, and indirect mortality costs of premature deaths caused by smoking-related diseases. Healthcare services comprise outpatient visits, inpatient

Tob Control: first published as 10.1136/tc.2010.042028 on 21 February 2011. Downloaded from http://tobaccocontrol.bmj.com/ on September 20, 2019 at MIT Libraries. Protected by copyright.

hospitalisations and self-medication. We used the prevalence-based, disease-specific approach to measure the costs of smoking-related diseases and deaths in a given year (2003 or 2008) caused by current and past smoking. Three kinds of smoking-related diseases were included: cancer (WHO International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) codes: C00–C97), cardiovascular diseases (ICD-10 codes: I00–I99) and respiratory diseases (ICD-10 codes: J00–J99). Because the average age at uptake for Chinese smokers was 21 years old,[11] and because smoking-related diseases usually occur after having smoked for a long time, we included only adults aged 35+ in the analysis.[12]

Smoking-attributable fraction (SAF)

We calculated the SAF for each component of the economic burden of smoking by disease category, rural/urban district, gender and age. Levin[13 14] developed the formula for 'attributable risk' to examine the proportion of lung cancer cases attributable to cigarette smoking. Attributable risk was first renamed the SAF in a computer software program, Smoking-Attributable Mortality, Morbidity, and Economic Cost (SAMMEC).[15–17] The SAF is specified by the following epidemiological formula:

$$SAF_{irsa} = \frac{(PN_{rsa} + PS_{rsa} \times RR_{irsa}) - 1}{(PN_{rsa} + PS_{rsa} \times RR_{irsa})} \quad (1)$$

where PN and PS denote the prevalence rate of never smokers and smokers, respectively; RR denotes the RR of mortality for smokers compared to never smokers; the subscript i is for disease category, r is for rural or urban district, s is for gender and a is for age, which is classified into two groups: ages 35–64 and ages 65+.

Data sources

The primary data used in this paper were drawn from the third and fourth waves of the NHSS conducted by the Ministry of Health in China in 2003 and 2008, respectively. The surveys used standardised questionnaires to collect individual's information including age, gender, education, employment status, disease histories, health risk behaviours use and expenditures for disease-specific outpatient visits and self-medication (not surveyed in 2008) in the 2 weeks before the date of interview, as well as disease-specific inpatient hospitalisations expenditures and number of inpatient days in the 12 months before the date of interview. Multistage stratified random sampling procedures and methods were used to select the samples. A total of 193 689 and 177 501 respondents aged 0 and above were sampled in 2003 and 2008, respectively.

Smoking prevalence rates by rural/urban district, gender and age came from the 2003 and 2008 NHSS in which all respondents aged 15+ were asked about their smoking status. We divided respondents into never smokers and smokers (including current and former smokers). We did not separate current smokers from former smokers because the RRs of mortality needed to calculate SAFs have not been estimated separately for former and current smokers in China. (Note that former smokers accounted for only a small proportion of ever smokers in China, ranging from 10.1% in 1998 to 8.6% in 2008. See the Results section for more details.) The RRs of the mortality for smoking came from a recent study by Gu *et al*[18] population data and disease-specific death rates in 2003 and 2008 were taken from China's Health Statistical Yearbook[19 20]; per capita family income, used to measure earnings for the indirect cost of mortality, was from the China Statistical Yearbook.[21 22] Life expectancy in 2003 came from the 2000 China Life Tables reported by the WHO, while the 2008 life expectancy was from WHO's 2008 China Life Tables.[23]

Direct costs

Direct costs include all the healthcare expenditures for treating smoking-related diseases. Three types of healthcare expenditures were available in the 2003 NHSS data: inpatient hospitalisations, outpatient visits and self-medication. However, only two types of healthcare expenditures were available in the 2008 NHSS data: inpatient hospitalisations and outpatient visits. The smoking-attributable expenditure (SAE) for each subgroup stratified by disease category, urban/rural district, gender and age was estimated by multiplying the SAF by the corresponding total healthcare expenditures according to the following formula:

$$\begin{aligned} SAE_{irsa} = {} & [PH_{irsa} \times QH_{irsa} + PV_{irsa} \times QV_{irsa} \times 26 \\ & + PM_{irsa} \times QM_{irsa} \times 26] \times POP_{rsa} \times SAF_{irsa} \end{aligned} \quad (2)$$

where PH is the average expenditure per inpatient hospitalisation; QH is the average number of hospitalisations per person in 12 months; PV is the average expenditure per outpatient visit; QV is the average number of outpatient visits per person in 2 weeks; PM is the average medication expenditures per person with positive self-medication expenditures in 2 weeks; QM is the proportion of persons with positive self-medication expenditures in 2 weeks; POP is the population in 2003 or 2008. The definition of subscripts is the same as with equation 1.

To assure that the self-reported health expenditures are a good proxy for actual expenditures, we applied an adjustment factor, which was determined as follows. First, we estimated the average per capita health expenditure for each disease category by urban/rural district, gender and age from the 2003 and 2008 NHSS data. Second, we multiplied this number by the population in 2003 and in 2008 for each subgroup and added all the expenditures across all subgroups to derive the estimated national health expenditures in 2003 and 2008. Finally, we calculated the adjustment factor by dividing the estimated national health expenditures by the official figures of national health expenditures[24] and then applied this adjustment factor to the estimated average expenditures from the NHSS data. The adjustment factor was 1.22 for 2003 and 1.30 for 2008.

Indirect morbidity costs

Smoking-attributable indirect morbidity costs (SAI) include transportation, nutritious supplemental food and caregiver costs during the inpatient hospitalisations and outpatient visits due to treating smoking-related diseases, and the value of lost productivity caused by smoking-related illness. We measured lost productivity by the number of days absent from work. Because days lost from work were not asked in the 2003 and 2008 NHSS, we used inpatient hospitalisation days as a proxy. The formula to estimate the SAI is as follows:

$$\begin{aligned} SAI_{irsa} = {} & [PHI_{irsa} \times QH_{irsa} + PVI_{irsa} \times QV_{irsa} \times 26 \\ & + IDAY_{irsa} \times E_{irsa} \times Y_{r}] \times POP_{rsa} \times SAF_{irsa} \end{aligned} \quad (3)$$

where PHI is the average expenditures for transportation, nutritious supplemental food and caregivers per inpatient hospitalisation; PVI is the average expenditure for transportation per outpatient visit; IDAY is the average number of annual inpatient days due to treating disease 'i' per employed person; E is the proportion of the total population currently employed; and Y is daily earnings measured by per capita family

Tob Control: first published as 10.1136/tc.2010.042028 on 21 February 2011. Downloaded from http://tobaccocontrol.bmj.com/ on September 20, 2019 at MIT Libraries. Protected by copyright.

income in 2003 or 2008. Other notations are the same as in equations 1 and 2.

Indirect mortality costs

The indirect mortality costs were estimated by four steps. First, the number of smoking-attributable deaths (SAD) was estimated by multiplying the SAF by total number of deaths for each 5-year age group from age 35–39 to age 85+ by population subgroups, as shown in equation 4. Second, the number of smoking-attributable years of potential life lost (SAYPLL) was estimated by the product of the SAD and the number of years of life expectancy remaining at the age of death by population subgroups, as shown in equation 5. Third, the present value of forgone lifetime earnings (PVLE) was estimated by 5-year age groups based on a human capital approach developed by Max and colleagues[25 26] as shown in equation 6. A discount rate of 3% was used to convert a stream of earnings into its current worth. To consider the potential growth of future earnings, we assumed an annual productivity growth rate of 10%, approximately the average growth rate of GDP in China between 2003 and 2008. Fourth, smoking-attributable mortality cost (SAMC) was estimated by the product of the SAD and PVLE as shown in equation 7. The formulae we used to estimate SAD, SAYPLL, PVLE and SAMC by disease category, urban/rural district, gender and age group are:

$$\mathrm{SAD}_{irsa} = [\mathrm{DRATE}_{irsa} \times \mathrm{POP}_{rsa}] \times \mathrm{SAF}_{irsa} \quad (4)$$

$$\mathrm{SAYPLL}_{irsa} = \mathrm{SAD}_{irsa} \times \mathrm{LE}_{sa} \quad (5)$$

$$\mathrm{PVLE}_{rsa} = \sum_{m=a}^{\mathrm{maxa}} [SURV_{rsa}(m)][\mathrm{Y}_r \times \mathrm{E}_{rs}(m)] \times (1+\mathrm{g})^{m-a}/(1+V)^{m-a} \quad (6)$$

$$\mathrm{SAMC}_{irsa} = \mathrm{SAD}_{irsa} \times \mathrm{PVLE}_{rsa} \quad (7)$$

where DRATE is death rate per 100 000 persons, LE is average number of years of life expectancy remaining at the age of death, SURV(m) is the probability that a person will survive to age m, maxa is the maximum 5-year age group (eg, age 85+), Y is per capita family income, E(m) is the proportion of the population of age m that is employed in the labour market, g is the growth rate of labour productivity, V is the discount rate, a is the age at death and other notations are the same as in equations 1 and 2.

Comparison of cost estimates across years

All the cost estimates are expressed in 2008 constant US\$. We first estimated the costs of smoking for 2003 and 2008 in terms of nominal Chinese Yuan. Then, the estimated 2003 costs of smoking were converted into 2008 constant Chinese Yuan by multiplying by 1.19 based on the Consumer Price Index (CPI) for 2003 and 2008 in China.[21] Finally, we applied the 2008 exchange rate of ¥6.9451 against US\$ to convert the costs into 2008 US\$. Since the 2000 costs of smoking were estimated in terms of 2000 US\$,[10] we first converted them back into 2000 Chinese Yuan by multiplying by the 2000 exchange rate of 8.2784. Then, following the process described above, we multiplied them by the ratio of the 2008 CPI to the 2000 CPI in China (1.20) and divided by the 2008 exchange rate of 6.9451.

RESULTS

In the last decade, China has experienced a rapid growth in the adult population aged 35+ and a significant increase in internal migration from rural to urban areas. The population of persons aged 35+ increased from 515.6 million in 2000 to 601.4 million (17% increase) in 2003 and to 724.2 million (40% increase) in 2008. In 2000, 63.8% of these adults lived in rural areas. That percentage dropped to 59.5% in 2003 and decreased further to 54.5% in 2008.[21 22 27] Because of the change in population mix, it is important to examine how smoking prevalence trends and patterns changed over the period, table 1 shows prevalence rates of ever smokers among adults aged 35+ by urban/rural district, gender, age and survey year according to the NHSS data. The prevalence rates for ever smokers decreased moderately from 38.0% (which included 34.5% as current smokers and 3.5% as former smokers) in 1998[10] to 33.1% (30.6% as current smokers and 2.5% as former smokers) in 2003 to 31.4% (28.7% as current smokers and 2.7% as former smokers) in 2008. The quit rate, expressed as a proportion of ever smokers who are former smokers, remained low, decreasing slightly from 10.1% in 1998 to 8.6% in 2008. Male smoking rates remained much higher than female smoking rates. For men, rural smoking rates were higher than urban smoking rates; the opposite was found for women. Smoking prevalence rates in 2008 were lower than in 2003 across all subgroups by urban/rural, gender and age except for women aged 35–64 in urban areas.

Table 2 shows the relative risks of mortality used in this study and the estimated SAFs calculated from equation 1. The relative risks of mortality for smokers were slightly higher for women and were highest for cancer. The SAFs were much smaller for women than men because smoking rates for women were much lower than for men. The SAFs in 2008 were lower than in 2003 except for women aged 35–64 in urban areas, a pattern mimicking that of smoking prevalence. Among the three disease categories, cancer showed the highest SAFs for men and women in 2008, ranging from a high of 25.7% for rural men aged 35–64 to a low of 2.2% for urban women aged 35–64.

As shown in table 3, in 2008, 552 280 deaths in China were attributed to smoking: 495 053 men and 57 227 women, 154 745 in urban areas and 397 535 in rural areas. This figure accounted for 8.9% of all deaths. By underlying cause of death, the majority of all smoking-attributable premature deaths were due to cancer (62%), followed by cardiovascular diseases (27%) and respiratory diseases (11%). The total number of smoking-attributable years of potential life lost (YPLL) was 8.5 million person-years so the average years of life lost per death was 15.4 years. While cancer caused 62% of smoking-attributable deaths, it accounted for 92% of the total smoking-attributable YPLL probably because most smokers who died of cancer died at a younger age than smokers who died from other causes.

Table 1 Ever-smoking prevalence rate (%) among adults aged 35 and older in China, by urban/rural district, gender, age and year

	2003	2008
Total	33.1	31.4
Female, rural	4.6	4.5
35–64	4.0	3.9
65+	7.8	7.2
Female, urban	5.3	4.7
35–64	3.5	3.7
65+	10.7	7.4
Male, rural	64.0	61.3
35–64	65.2	62.9
65+	58.0	54.0
Male, urban	56.1	53.0
35–64	60.3	58.1
65+	42.3	37.1

Tob Control: first published as 10.1136/tc.2010.042028 on 21 February 2011. Downloaded from http://tobaccocontrol.bmj.com/ on September 20, 2019 at MIT Libraries. Protected by copyright.

Tob Control: first published as 10.1136/tc.2010.042028 on 21 February 2011. Downloaded from http://tobaccocontrol.bmj.com/ on September 20, 2019 at MIT Libraries. Protected by copyright.

Table 2 Disease-specific relative risk of mortality for ever smokers and smoking-attributable fractions (SAFs) in China, 2008, by disease, urban/rural district, gender and age for adults aged 35 and older

	RR*		SAF (%)							
			Urban				Rural			
			Male		Female		Male		Female	
	Male	Female	35–64	65+	35–64	65+	35–64	65+	35–64	65+
2003										
Respiratory diseases	1.14	1.43	7.78	5.59	1.48	4.40	8.36	7.51	1.69	3.25
Cardiovascular diseases	1.17	1.21	9.30	6.71	0.73	2.20	9.98	8.98	0.83	1.61
Cancer	1.55	1.62	24.91	18.87	2.12	6.22	26.39	24.18	2.42	4.61
2008										
Respiratory diseases	1.14	1.43	7.52	4.93	1.57	3.08	8.09	7.03	1.65	3.00
Cardiovascular diseases	1.17	1.21	8.99	5.93	0.77	1.53	9.66	8.41	0.81	1.49
Cancer	1.55	1.62	24.22	16.95	2.24	4.39	25.70	22.90	2.36	4.27

*Source: Gu *et al*.[18]

Table 4 shows the estimated economic costs of smoking in 2008 by component of costs, gender, age, urban/rural district and disease according to equations 2-3. The total economic costs of smoking in 2008 amounted to $28.9 billion: $6.2 billion (21.5%) in direct costs, $22.0 billion (76.1%) in indirect mortality costs and $0.7 billion (2.4%) in indirect morbidity costs.

The $28.9 billion of total economic costs in 2008 represented 0.7% of China's GDP ($4360.7 billion).[21] According to the NHSS data, the economic cost of smoking on average was $21.70 for each Chinese (=$28.9 billion /1.33 billion of total population) or $127.30 per smoker for the 227 million current smokers aged 35 and older in 2008. Because China's total consumption of cigarettes in 2008 was 2139 billion sticks (107.0 billion packs),[21] the total economic costs of smoking averaged $0.27 per pack, about 8.1% of the 2006 average retail price of class A cigarettes per pack in China (¥26.7 or $3.35) and about 43% of the price of class B cigarettes per pack (¥5.0 or $0.63).[28] A larger share of the total economic costs of smoking was borne by men than women ($26.9 billion versus $2.0 billion) and by the middle-aged group than the older age group ($24.1 billion vs $4.7 billion). Cancer comprised the highest proportion of the total economic costs in 2008: $19.7 billion (68.2%), followed by cardiovascular diseases at $7.2 billion (24.9%) and respiratory diseases at $2.0 billion (6.9%).

The $6.2 billion of direct costs of smoking in 2008 accounted for 3.0% of China's national healthcare expenditures ($209.3 billion):[24] 73% of the direct costs of smoking were spent on outpatient visits while 27% was spent on inpatient care.

The 8-year comparison

Table 5 shows that the absolute number of smoking-attributable deaths decreased from 2000 to 2003 and then continued to fall from 2003 to 2008. This drop in deaths was due mainly to the declining trends in smoking prevalence and the resulting decrease in SAFs during the 8-year period. For example, the SAF for cancer among urban men aged 35–64 declined from 28.9% in 2000 to 24.9% in 2003 and declined again to 24.2% in 2008. Compared to 2000, the smoking-attributable YPLL in 2003 decreased by 15.8% because of the declining SAFs and the use of the same life expectancy data for 2000 and 2003. However, the YPLL rose between 2003 and 2008 even though the number of smoking-attributable deaths fell. This resulted because updated life expectancy data were available in 2008,[23] and they revealed a substantial increase in life expectancy among Chinese from 68.9 years for men and 73.0 years for women in 2000 to 72.1 years for men and 75.7 years for women in 2008.

Table 3 Number of deaths and years of potential life lost (YPLL) attributable to smoking in China, 2008, by urban/rural district, gender, age and disease among adults aged 35 and older

	Deaths	YPLL
Male	495 053	7 785 011
Female	57 227	720 609
35–64	215 994	5 340 087
65+	336 286	3 165 533
Urban	154 745	2 396 498
Rural	397 535	6 109 122
Respiratory diseases	61 514	628 559
Cardiovascular diseases	147 792	1 882 707
Cancer	342 974	5 994 354
Total	552 280	8 505 620

Compared to 2000, the total economic costs of smoking rose by 137% in 2003 and 300.7% in 2008. From 2000 to 2003, the direct costs of smoking costs increased by 72%. Smoking-attributable inpatient hospitalisation costs fell by 30%, perhaps because of the decrease in the hospitalisation rate.[11] The smoking-attributable self-medication costs grew dramatically by 393% during this period. From 2000 to 2008, the direct costs of smoking increased by 154% and smoking-attributable outpatient costs alone increased by 253%. Compared to 2000, indirect mortality costs of smoking increased by 199% in 2003 and by 424% in 2008; the smoking-attributable costs of absence from work were lower in 2003 and 2008 probably because they were based on inpatient days instead of work loss days; the smoking-attributable costs for transportation and caregivers decreased slightly by 15% in 2003 but increased by 119% in 2008.

DISCUSSION

The total economic cost of smoking for 2008 in China was $28.9 billion, accounting for 0.7% of China's GDP and averaging $127.30 per smoker. Among the different components of smoking-attributable costs, mortality costs ranked first, followed by outpatient expenditures. Alarmingly, 93.1% of the total economic cost of smoking in China was borne by men in 2008 because of their high smoking prevalence rate. Our results indicate that smoking is a matter of public health concern, which deserves attention, and has also already exerted a huge financial burden on the Chinese economy.

The direct costs of smoking in 2008 accounted for 3.0% of total national healthcare expenditures in China. This proportion is similar to that estimated by Sung *et al* (3.1%).[10] Yet it is lower than the 4.3% in Vietnam,[29] 4.7% in India,[30] and 6% to 8% in the US.[31] Our estimates for the total direct and indirect costs of smoking are very likely underestimated for several reasons.

Table 4 Economic costs of smoking in China, 2008, by component of costs, urban/rural district, gender, age and disease for adults of age 35 and older in US$1000

	Direct medical cost			Indirect cost				
				Indirect morbidity cost				
	Outpatient	Inpatient	Subtotal	Transportation and care givers	Absence from work	Indirect mortality costs	Subtotal	Total
Male	4 054 280	1 483 162	5 537 442	332 547	226 410	20 778 363	21 337 320	26 874 762
Female	485 233	178 926	664 159	50 741	35 842	1 226 432	1 313 015	1 977 174
35−64	2 453 321	985 257	3 438 578	252 682	218 471	20 202 605	20 673 758	24 112 336
65+	2 086 192	676 831	2 763 023	130 606	43 781	1 802 190	1 976 577	4 739 600
Urban	1 999 408	835 647	2 835 055	136 550	71 405	10 471 987	10 679 942	13 514 997
Rural	2 540 105	826 441	3 366 546	246 738	190 847	11 532 808	11 970 393	15 336 939
Respiratory diseases	761 862	172 042	933 904	77 121	113 266	833 698	1 024 085	1 957 989
Cardiovascular diseases	2 177 300	729 573	2 906 873	170 861	111 062	4 007 352	4 289 275	7 196 148
Cancer	1 600 351	760 473	2 360 824	135 306	37 924	17 163 745	17 336 975	19 697 799
Total	4 539 513	1 662 088	6 201 601	383 288	262 252	22 004 795	22 650 335	28 851 936

Exchange rate of the Chinese Yuan against US$=¥6.9451 in 2008 based on China Statistical Yearbook, 2009.[21]

First, our estimation for the costs attributable to smoking considered only the three major categories of smoking-related diseases. Smoking increases the risk of many other diseases such as hip fractures, gum diseases, nasal irritation, nuclear cataract and Graves' ophthalmopathy, reproductive and erectile dysfunction problems, and peptic ulcers.[5] The omission of these diseases certainly results in underestimating the true costs of smoking.

Second, this study did not consider the economic burden from passive smoking. A recent study in Hong Kong found that this burden represented 23% of the total medical costs of active and passive smoking.[32] In China, 540 million persons (aged 0 and older) are exposed to passive smoking.[33] Thus, ignoring the economic impact of passive smoking underestimates the direct costs of smoking.

Third, the RR of mortality was an important element in estimating the SAF. The bigger this value, the larger the SAF. In this study, we used the RRs from a prospective cohort study in a nationally representative sample of Chinese adults aged 40+ with baseline data collected in 1991 and follow-up evaluation collected in 1999−2000.[18] The study's RR estimates for China were lower than those of other countries. For example, their RR estimate of lung cancer mortality in China for ever smokers relative to never smokers was 2.44 for men and 2.76 for women.[18] According to an American study, the corresponding RR estimate was 23.26 for current male smokers, 8.7 for former male smokers, 12.69 for current female smokers and 4.53 for former female smokers.[34] The RR estimate of respiratory diseases in China for ever smokers was 1.14 for men and 1.43 for women; however, a recent nationally representative case-control study of smoking and mortality conducted in India estimated the corresponding RR in India to be 2.1 for men and 3.1 for women.[35]

Fourth, it is particularly worth noting that according to the 2008 NHSS data, 10.6% of Chinese citizens aged 15 and older who reported having medical conditions in the previous 2 weeks did not get any treatment in China in 2008, and 27.2% of Chinese citizens who reported a need for hospitalisation during the previous year were not hospitalised.[11] The corresponding figures in 2003 were 13.1% and 29.6%, respectively. These data suggest that smoking-attributable diseases might have occurred among these two groups of people, yet they did not use healthcare services. If this potential demand for healthcare services is transformed into real demand, smoking will impose a greater healthcare burden on the economy.

Finally, this study did not consider days lost from work by relatives or informal caregivers who took care of the patients with smoking-related illness. In addition, due to the lack of work loss data, the productivity losses due to smoking-caused disability other than inpatient hospitalisation days were not considered. Therefore, the actual indirect morbidity costs of smoking-attributable diseases should be higher than our estimates (see more discussion below).

Our 2003 and 2008 cost estimates can be directly compared to the 2000 costs estimated by Sung *et al*[10] because both studies employed the same methodologies with two exceptions. First, our study used the RRs of mortality for smoking from a more recent study by Gu *et al*[18] rather than from Liu *et al*[36] as did Sung

Table 5 Comparison of smoking-attributable deaths, years of potential life lost and economic costs in 2000, 2003 and 2008

	2000	2003	2008	Percentage change 2000−2003	Percentage change 2000−2008
Mortality	688 512	574 107	552 280	−16.62	−19.79
YPLL	9 699 251	8 162 771	8 505 620	−15.84	−12.31
Direct costs	2 439 796	4 198 072	6 201 601	72.07	154.19
Outpatient visits	1 285 832	2 472 829	4 539 513	92.31	253.04
Inpatient hospitalisation	936 051	651 875	1 662 088	−30.36	77.56
Self-medication	217 913	1 073 368	–	392.57	–
Indirect costs	4 761 023	12 871 102	22 650 335	170.34	375.75
Transportation and care givers	175 169	149 348	383 288	−14.74	118.81
Absence from work	387 006	159 392	262 252	−58.81	−32.24
Mortality	4 198 848	12 562 362	22 004 795	199.19	424.07
Total	7 200 819	17 069 174	28 851 936	137.04	300.68

Exchange rate of the Chinese Yuan against US$=¥6.9451 in 2008 based on China Statistical Yearbook, 2009.[21]

Tob Control: first published as 10.1136/tc.2010.042028 on 21 February 2011. Downloaded from http://tobaccocontrol.bmj.com/ on September 20, 2019 at MIT Libraries. Protected by copyright.

et al. If we had used the RR data from Liu *et al*[36] then the total economic cost of smoking in China in 2008 would be $23.0 billion instead of $28.9 billion, direct healthcare costs would be $5.2 billion instead of $6.2 billion, and indirect morbidity and mortality costs would be $17.8 billion instead of $22.7 billion. Therefore, part of the increases in the costs of smoking between 2000 and 2008 was due to the use of more recent RR data, which we believe better capture the impact of smoking during the study period. Second, this study measured lost productivity by inpatient days as a proxy for work loss days[10] because the latter variable was not asked in the 2003 and 2008 NHSS. According to a published report based on the second wave of the NHSS data,[37] the annual average inpatient days in China were lower than the annual average work loss days by 23% for cancer, 41% for cardiovascular diseases and 60% for respiratory diseases. Therefore, our estimates for the 2003 and 2008 indirect costs of absence from work could be underestimates by at least 23%.

During the 8 years from 2000 to 2008, smoking-attributable deaths decreased by 20%, but the mortality costs of smoking increased by 424%. The decrease in smoking-attributable deaths is a consequence of the reduced smoking prevalence and the resultant decrease in SAFs plus the reduced death rates for cancer, cardiovascular and respiratory diseases.[19 20] The increase in the mortality costs of smoking is due mainly to the substantial increase in labour costs measured by per capita family income, which doubled from 2000 to 2003 and quadrupled from 2000 to 2008 in urban districts and which increased by 10% from 2000 to 2003 and by 96% from 2000 to 2008 in rural districts.[21 22 27] The direct healthcare cost of smoking rose by 72% from 2000 to 2003 and by 154% from 2000 to 2008. This large increase occurred because China's national healthcare expenditures increased dramatically from ¥550 billion in 2000 to ¥784 billion in 2003 and ¥1454 billion in 2008 (all expressed in 2008 constant Yuan), as a result of introducing high-tech medical equipment, the rising prices of healthcare services and the growth of the population aged 35+.[20] The increases in per capita family income and national healthcare expenditures were contributors to the prominent growth of China's national economy during the last decade.

In summary, our results indicate that smoking imposes a substantial burden on Chinese society. We found that the economic burden of smoking increased substantially during the 8 years from 2000 to 2008 and that the increase was due largely to China's rapid economic growth. If China's economy continues to grow, the economic costs of smoking in the future will escalate if smoking prevalence cannot be substantially reduced. In the era of fast economic growth in China, stronger tobacco control measures must be taken without delay. Although currently 7.0% of China's central government total revenue is generated from tobacco profit and taxes ($64.8 billion in 2008), this share has been shrinking in recent years.[21] Tobacco's contribution is expected to shrink more in the future with the growth in the national economy, high tech and other industries as observed in developed countries. Regardless, policymakers should understand the negative impact of cigarette smoking on China's financial burden. Raising tobacco excise taxes has been proven as the most effective tobacco control measure to reduce tobacco use while raising government tax revenue.[38] China currently levies a 76.7% tax rate at the producer level, equivalent to a 43.4% tax rate at the retail level,[39] which is a relatively low rate compared to cigarette tax rates around the world, the median of which is about 60%.[40] This relatively low rate suggests ample room for tobacco tax increases in China especially for class B cigarettes. Moreover, our results show that the total economic burden of smoking averaged $0.27 per pack (or 43% of the class B cigarette retail price per pack in 2006). As explained above, because our cost estimates are underestimated, the true burden of smoking could be much higher than $0.27 per pack. Therefore, the Chinese government should raise tobacco taxes on the retail price of class B cigarettes without delay. Such an increase will help to offset the health-related financial losses to the society due to smoking and reduce cigarette smoking and its huge health-related financial burden. From an equity perspective, part of the tax revenues raised should be used to help remaining smokers quit and obtain healthcare for treating smoking-related illnesses that they may already have.

What this paper adds

This paper updates the estimates for the economic costs attributable to smoking in China until 2008, and compares the trends between 2000, 2003, and 2008. We found the economic burden of cigarette smoking has increased substantially in China during the past decade and that the increase was due largely to China's rapid economic growth. Our findings underscore the importance of stronger tobacco control measures especially in the era of fast economic growth in China.

Acknowledgements This study was sponsored by the China Medical Board News and partially supported by the US National Institutes of Health, Fogarty International Center, grant no. N01-TW05938. The authors are grateful to Section Chief Ling Xu and Master Yaoguang Zhang, Centre of Health Statistics and Information, Ministry of Health, China, for their advice and support during the process of data analysis.

Funding N01-TW05938. Other funders: National Institutes of Health; China Medical Board News.

Competing interests None.

Patient consent Obtained.

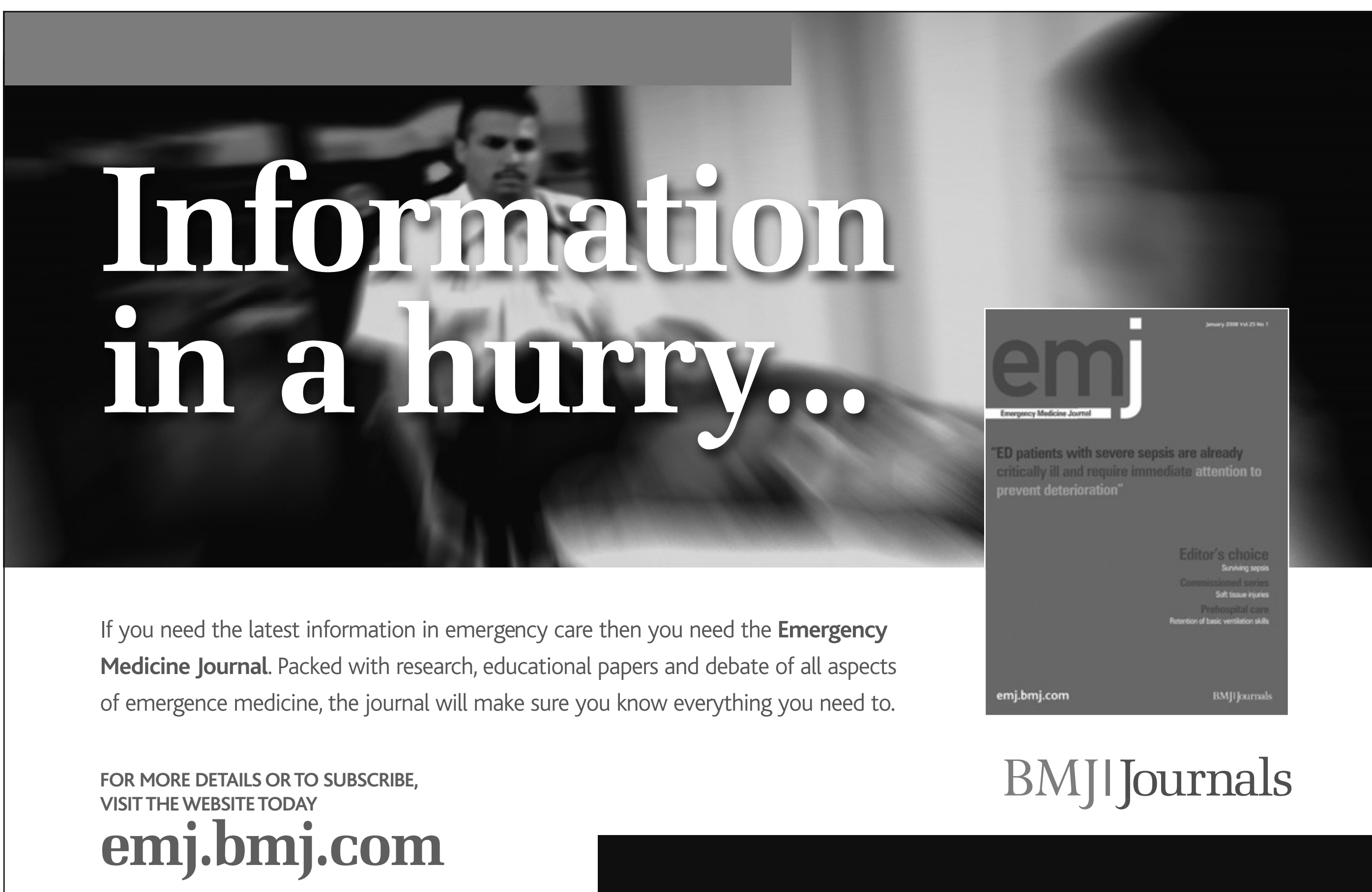
Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1. **Chinese Center for Disease Control and Prevention.** *Global Adult Tobacco Survey (GATS) Fact Sheet China*. 2010. http://www.cdc.gov/tobacco/global/gats/countries/wpr/fact_sheets/china/2010/index.htm (accessed 12 Sep 2010).
2. **Doll R,** Hill AB. A study of the aetiology of carcinoma of the lung. *BMJ* 1952;**4797**:1271—86.
3. **Gao YT,** McLaughlin JK, Blot WJ, *et al*. Risk factors for esophageal cancer in Shanghai, China. I. Role of cigarette smoking and alcohol drinking. *Int J Cancer* 2006;**58**:192—96.
4. **Proia NK,** Paszkiewicz GM, Nasca MA, *et al*. Smoking and smokeless tobacco-associated human buccal cell mutations and their association with oral cancer—A review. *Cancer Epidemiol Biomarkers Prev* 2006;**15**:1061—77.
5. **US Department of Health and Human Services.** *The health consequences of smoking: a report of the Surgeon General*. Atlanta, Georgia: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2004.
6. **Niu SR,** Yang GH, Chen ZM, *et al*. Emerging tobacco hazards in China. 2. Early mortality results from a prospective study. *BMJ* 1998;**317**:1423—4.
7. **Hu TW,** Mao Z, Ong M, *et al*. China at the crossroads: the economics of tobacco and health. *Tob Control* 2006;**15**(Suppl I):i37—41.
8. **Chen J,** Cao JW, Chen Y, *et al*. Evaluation of medical cost lost due to smoking in Chinese cities. *Biomed Environ Sci* 1995;**8**:335—41.
9. **Jin SG,** Lu BY, Yan DY, *et al*. An evaluation of smoking-induced health costs in China (1988-1989). *Biomed Environ Sci* 1995;**8**:342—9.
10. **Sung HY,** Wang L, Jin S, *et al*. Economic burden of smoking in China, 2000. *Tob Control* 2006;**15**(Suppl I):i5—i11.
11. **Ministry of Health, People's Republic of China.** *An Analysis Report of National Health Services Survey in 2008*. Beijing: Peking Union Medical College Press, 2010.
12. **Kang HY,** Kim HJ, Park TK, *et al*. Economic burden of smoking in Korea. *Tob Control* 2003;**12**:37—44.

Tob Control: first published as 10.1136/tc.2010.042028 on 21 February 2011. Downloaded from http://tobaccocontrol.bmj.com/ on September 20, 2019 at MIT Libraries. Protected by copyright.

13. **Levin ML.** The occurrence of lung cancer in man. *Acta Unio Int Contra Cancrum* 1953;**9**:531—41.
14. **Lilienfeld AM,** Lilienfeld DE. *Foundations of Epidemiology*, 3rd edn. New York: Oxford University Press, 1994:202.
15. **Shultz JM.** *SAMMEC: Smoking-attributable mortality, morbidity, and economic costs (computer software and documentation)*. Minneapolis: Minnesota Department of Health, Center for Nonsmoking and Health, 1986.
16. **U.S. Centers for Disease Control and Prevention (CDC).** Current trends state-specific estimates of smoking-attributable mortality and years of potential life lost — United States, 1985. *MMWR* 1988;**37**:689—93.
17. **Shultz JM,** Novotny TE, Rice DP. Quantifying the disease impact of cigarette smoking with SAMMEC II software. *Public Health Rep* 1991;**106**:326—33.
18. **Gu DF,** Kelly TN, Wu XG, *et al*. Mortality attributable to smoking in China. *N Engl J Med* 2009;**360**:150—9.
19. **Ministry of Health, People's Republic of China.** *China's Health Statistical Yearbook 2004*. Beijing: Ministry of Health, 2004.
20. **Ministry of Health, People's Republic of China.** *China's Health Statistical Yearbook 2009*. Beijing: Ministry of Health, 2009.
21. **National Bureau of Statistics of China.** *China Statistical Yearbook 2009*. Beijing: China Statistics Press, 2009.
22. **National Bureau of Statistics of China.** *China Statistical Yearbook 2004*. Beijing: China Statistics Press, 2004.
23. **World Health Organization.** Life tables for WHO member states in 2000 and in 2008. http://apps.who.int/whosis/database/life_tables/life_tables.cfm (accessed 5 May 2010).
24. **China National Health Economic Institute.** *China National Health Accounts Digest*. Beijing: China Statistics Press, 2009.
25. **Max W,** Rice DP, Sung HY, *et al*. The economic burden of smoking in California. *Tob Control* 2004;**13**:264—7.
26. **Max W,** Rice DP, Sung H-Y, *et al*. *Valuing Human Life: Estimating The Present Value Of Lifetime Earnings*. San Francisco: University of California, Institute for Health and Aging, 2004b. http://repositories.cdlib.org/ctcre/esarm/PVLE2000 (accessed 16 Oct 2009).
27. **National Bureau of Statistics of China.** *China Statistical Yearbook 2001*. Beijing: China Statistics Press, 2001.
28. **Hu AG,** Hu LL. Tobacco control policy analysis in China: taxes and price. *Jia Ge Li Lun Yu Shi Jian* 2009;**11**:27—8 (in Chinese).
29. **Ross H,** Trung DV, Phu VX. The costs of smoking in Vietnam: the case of inpatient care. *Tob Control* 2007;**16**:405—9.
30. **John RM,** Sung HY, Max W. Economic cost of tobacco use in India, 2004. *Tob Control* 2009;**18**:138—43.
31. **Warner KE,** Hodgson TA, Carroll CE. Medical costs of smoking in the United States: estimates, their validity, and their implications. *Tob Control* 1999;**8**:290—300.
32. **McGhee SM,** Ho LM, Lapsley HM, *et al*. Cost of tobacco-related diseases, including passive smoking, in Hong Kong. *Tob Control* 2006;**15**:125—30.
33. **Yang GH,** Ma JM, Liu N, *et al*. Smoking and passive smoking in China, 2002. *Zhonghua Liu Xing Bing Xue Za Zhi* 2005;**26**:77—83 (in Chinese).
34. **Centers for Disease Control and Prevention.** *Adult SAMMEC: Smoking-Attributable Mortality, Morbidity, And Economic Costs (Online Software)*. Atlanta, GA: Centers for Disease Control and Prevention, 2010. https://apps.nccd.cdc.gov/sammec/edit_risk_data.asp (accessed 7 May 2010).
35. **Jha P,** Jacob B, Gajalakshmi V, *et al*. A nationally representative case—control study of smoking and death in India. *N Engl J Med* 2008;**358**:1137—47.
36. **Liu BQ,** Peto R, Chen ZM, *et al*. Emerging tobacco hazards in China: 1. Retrospective proportional mortality study of one million deaths. *BMJ* 1998;**317**:1411—22.
37. **Ministry of Health**, *People's Republic of China. Research on National Health Services—an analysis report of the Second National Health Services Survey in 1998*. Beijing: National Center for Health Information and Statistics, 1999.
38. **Hu TW,** Mao ZZ, Shi J, *et al*. *Tobacco taxation and its potential impact in China*. Paris: International Union Against Tuberculosis and Lung Disease, 2008.
39. **Hu TW,** Mao ZZ, Shi J. Recent tobacco tax rate adjustment and its potential impact on tobacco control in China. *Tob Control* 2010;**19**:80—2.
40. **Mackay J,** Eriksen M. *The tobacco atlas.* Geneva: World Health Organization, 2002:94—5.



Tob Control: first published as 10.1136/tc.2010.042028 on 21 February 2011. Downloaded from http://tobaccocontrol.bmj.com/ on September 20, 2019 at MIT Libraries. Protected by copyright.