RESEARCH PAPER

Economic burden of smoking in China, 2000

H-Y Sung, L Wang, S Jin, T-W Hu, Y Jiang

Tobacco Control 2006;**15**(Suppl I):i5–i11. doi: 10.1136/tc.2005.015412

See end of article for authors' affiliations

Correspondence to: Hai-Yen Sung, PhD, Institute for Health & Aging, UCSF, 3333 California Street, Suite 340, San Francisco, CA 94118, USA; Hai-Yen.Sung@ucsf.edu

Objective: To assess the health-related economic burden attributable to smoking in China for persons aged 35 and older.

Methods: A prevalence-based, disease-specific approach was used to estimate the smoking attributable direct costs, indirect morbidity costs, and costs of premature deaths caused by smoking-related diseases. The primary data source was the 1998 China National Health Services Survey, which contains the smoking status, medical utilisation, and expenditures for 216 101 individuals.

Results: The economic costs of smoking in 2000 amounted to $5.0 billion (measured in 2000, US$) in total and $25.43 per smoker (⩾ age 35). The share of the economic costs was greater for men than women, and greater in rural areas than in urban areas. Of the $5.0 billion total costs, direct costs were $1.7 billion (34% of the total), indirect morbidity costs were $0.4 billion (8%), and indirect mortality costs were $2.9 billion (58%). The direct costs of smoking accounted for 3.1% of China's national health expenditures in 2000.

Conclusion: The adverse health effects of smoking constitute a huge economic burden to the Chinese society. To reduce this burden in the future, effective tobacco control programmes and sustained efforts are needed to curb the tobacco epidemic and economic losses.

China is the world's largest tobacco consumer, accounting for more than one fourth of the world's tobacco consumption annually. In 2002, about 350 million adults aged 15 and older were ever smokers and 300 million were current smokers.[1] China is considered in an early stage of a tobacco epidemic. The ever-smoking rates in 2002 were 66.0% for men and 3.1% for women of ages 15 years and older, slightly lower than the rates in 1996 of 66.9% for men and 4.2% for women. The prevalence of smoking in Chinese men seems to have levelled off but not yet dropped. The average cigarette consumption per smoker was the same in 2002 as that in 1996—14.8 cigarettes per day.

Cigarette smoking is the leading cause of preventable deaths in the majority of high-income nations and increasingly in low- and middle-income nations,[2] and it also causes disability and productivity losses because of premature deaths.[3] One way to document and assess the adverse health effects of smoking on a society is to translate smoking-caused illnesses, premature mortality, and productivity losses into economic terms. In other words, the cost of smoking serves as a universal marker for measuring the adverse effects of smoking.

Only two studies have estimated the economic costs of smoking in China. Chen *et al*,[4] using a medical cost accounting method to calculate the disease-specific medical costs, estimated the total medical costs attributable to smoking in 1988 as 2.3 billion Yuan (US$0.3 billion using an exchange rate of 8.2784 Yuan to US$1). Using a prevalence-based method, Jin *et al*[5] estimated the total economic burden of smoking in 1989 at 27.1 billion Yuan (US$3.3 billion), including 6.9 billion Yuan (US$0.8 billion) in direct medical costs and 20.1 billion Yuan (US$2.4 billion) in indirect morbidity and mortality costs. During the decade since these two studies, medical expenditures have risen dramatically, and smoking prevalence rates have also increased. To improve public health and reduce resources spent for smoking-caused illness, we must monitor the progression of the economic burden caused by cigarette smoking and update the estimates for the costs of smoking.

The objective of this study is to assess the economic burden of diseases and deaths attributable to smoking on Chinese society in 2000. The results may be used to justify the need for stronger tobacco control policies in China and guide health policy and planning.

METHODS

The economic burden of smoking comprises three components: direct medical costs of treating smoking-related diseases, indirect morbidity costs of smoking, and indirect mortality costs of premature deaths caused by smoking-related diseases. We used the prevalence-based, disease-specific approach[6–9] to measure the costs of smoking-related diseases and deaths in 2000 caused by current and past smoking. Three major categories of smoking-related diseases were considered: cancer (all types of malignant neoplasm (*International classification of diseases*, 9th revision (ICD-9) codes: 140–208)), cardiovascular diseases (stroke, ischaemic heart disease, rheumatic heart disease, etc (ICD-9 codes: 390–414, 418–459)), and respiratory diseases (chronic obstructive pulmonary disease, respiratory tuberculosis, pulmonary heart disease, etc (ICD-9 codes: 011–012, 018, 415–417, 460–519)). Because the effects of smoking will appear long after its onset, and because most smokers begin before age 20, we included only persons aged 35 and older in the analysis.

Estimation of smoking attributable fraction

For each of the three components of the economic burden of smoking, we calculated a smoking attributable fraction (SAF), also known as population attributable risk, by disease category, rural/urban district, gender, and age. The estimated SAF is then multiplied by each cost measure of interest to derive the smoking attributable cost.[10] For example, the product of SAF and total inpatient hospitalisation expendi-

Abbreviations: GDP, gross domestic product; ICD-9, *International classification of diseases*, 9th revision; NHSS, National Health Services Survey; PVLE, present value of lifetime earnings; RR, relative risk; SAF, smoking attributable fraction; SAI, smoking attributable indirect morbidity cost; THE, total health care expenditure; TIE, total indirect morbidity expenditure; YPLL, years of potential life lost tures is smoking attributable hospitalisation cost; the product of SAF and total morbidity cost is smoking attributable morbidity cost. The SAF is specified by the following epidemiological formula[11]:

$$SAF_{ijga} = \frac{(PN_{jga} + PS_{jga}{}^{*}RR_{ijga}) - 1}{PN_{jga} + PS_{jga}{}^{*}RR_{ijga}} \qquad (1)$$

where PN and PS denote the prevalence rate of non-smokers and smokers, respectively; RR denotes the relative risk of mortality for smokers compared to non-smokers; the subscript i is for disease category; j is for rural/urban district; g is for gender; a is for age classified into two groups, 35–64 and 65+. When RR is < 1, the corresponding SAF becomes negative, implying that smokers have a decreased risk of mortality compared with non-smokers. This implication does not seem realistic, given the huge body of evidence linking smoking with multiple life-threatening diseases. Instead of employing negative SAFs, we assume they are zero.

We estimated SAFs using the RRs of mortality and then applied the same SAF estimates to the total measure for all three components of the economic costs.

Data source

The primary data source was the Second National Health Services Survey (NHSS) conducted by the Ministry of Health in China in 1998.[12] The NHSS is a nationally representative sample of 216 101 individuals from 56 994 households extracted through a multi-stage random sampling method. Face-to-face interviews were conducted to collect detailed information about households and all household members. Such information includes age, gender, education, employment status, disease histories, health risk behaviours, and medical care utilisation and expenditures including cause-specific outpatient visits and self-medication in the two weeks before the date of interview, as well as inpatient hospitalisations in the past 12 months before the date of interview. Self-reported days lost from work due to illness in the past two weeks before interview were also collected.

Smoking prevalence rates by rural/urban district, gender, and age came from the 1998 NHSS in which all the individuals of age 15 and older were asked their smoking status. We classified adults as non-smokers (never smoked) and smokers (current and former). We did not separate current smokers from former smokers because the RRs of mortality, needed in the calculation of SAFs, have not been estimated separately for former and current smokers in China.

The RRs of mortality for smokers were obtained from published estimates by Liu *et al*,[13] population data from the 2000 Population Census,[14] 2000 mortality rates from China's Vital Registration system monitored by the Ministry of Health,[15] life expectancy from the 2000 China Life Tables reported by the World Health Organization,[16] and earnings data from the China Statistics Yearbook.[17]

Direct costs

Direct costs include all the health care expenditures for treating smoking-related diseases. China has three types of health care services: inpatient hospitalisations, outpatient visits, and self-medications. Hospitalisation and outpatient costs include expenditures for prescribed medicine during the hospital stays or outpatient visits. Self-medications refer to medicine purchased by patients from a drug store without seeing a doctor.

Smoking attributable health care expenditure (SAE) for each subgroup stratified by disease category, urban/rural district, gender, and age (35–64, and 65+) was estimated by multiplying the SAF by the corresponding total health care expenditure (THE) according to the following formula:

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

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 two weeks; PM is the average medication expenditure per person with positive self-medication expenditures in two weeks; QM is the proportion of persons with positive self-medication expenditures in two weeks; and POP is the 2000 population. The notation for the subscripts i, j, g, and a is the same as in equation 1.

The average expenditures and health care utilisation rates were estimated from the 1998 NHSS data. In the NHSS questionnaire, respondents were asked to report the expenditures of inpatient hospitalisations and the amount paid by health insurance and by their own. Because of the logic of the questionnaire structure, we consider that the self-reported hospitalisation expenditures represent actual expenditures including payment from insurance and out-of-pocket. For self-medications, the total expenditures were not likely paid by insurance since they were purchased without doctor's prescription. For two-week outpatient visits, respondents were asked to report the total expenditures without being probed for the out-of-pocket payment or health insurance payment.

To warrant that the self-reported health expenditures are a good proxy for actual expenditures, we undertook an adjustment process. First, we estimated the average per capita health expenditure for each disease category by urban/rural district, gender and age from the 1998 NHSS data. Second, we multiplied this number by the population in 2000 for each subgroup and added up all the expenditures across all subgroups to derive the estimated national health expenditure in 2000. Our estimate is $40.2 billion, which is lower than the published figure at $55.4 billion.[18] Finally, we calculated an adjustment factor of 1.38 (55.4/40.2) and applied it to the estimated average expenditures from the NHHS data.

Indirect morbidity costs

Indirect morbidity costs include expenditures for transportation and caregivers due to inpatient hospitalisations and outpatient visits as well as the value of lost productivity caused by smoking-related diseases.

Smoking attributable indirect morbidity cost (SAI) for each subgroup stratified by disease category, urban/rural district, gender, and age (35–64, and 65+) was estimated by multiplying the SAF by the corresponding total indirect morbidity expenditure (TIE) using the following formula:

$$\begin{aligned} SAI_{ijga} &= TIE_{ijga} \times SAF_{ijga} \\ &= [PHI_{ijga} \times QH_{ijga} + PVI_{ijga} \times QV_{ijga} \times 26 \\ &\quad + PW_{ijga} \times QW_{ijga} \times 26 \times Y_j] \times POP_{ijga} \times SAF_{ijga} \end{aligned} \qquad (3)$$

where PHI is the average expenditure on transportation and caregivers per inpatient hospitalisation; PVI is the average expenditure on transportation per outpatient visit; PW is the average number of days lost from work due to smoking-related illness per employed person in two weeks; QW is the employment-population ratio which is defined as the proportion of the total population who are currently employed; and Y is daily earnings in 2000.

The expenditures for transportation and caregivers and the days lost from work were from the 1998 NHSS data. Since average earnings data were not available by age and gender, we evaluated the work-loss days using two sets of 2000 earnings data: average annual wage of the staff and workers for urban residents, and per capita annual net income of rural households multiplied by the average number of rural residents supported by the rural working population.[17] Daily earnings were derived by dividing the annual earnings by 366 (number of days in 2000).

Indirect mortality costs

We used the human capital approach[19] to measure the expected value of lost future productivity caused by smoking attributable premature deaths in 2000. Smoking attributable deaths for each subgroup stratified by disease category, urban/rural district, gender, and age (35–64, and 65+) were estimated by multiplying the SAFs by the corresponding total number of deaths. Smoking attributable years of potential life lost (YPLLs) were estimated by the product of smoking attributable deaths and the average number of years of life expectancy remaining at the age of death. Life expectancy was obtained from gender and five-year age-specific life tables for China in 2000.[16]

Smoking attributable costs of premature deaths were estimated by multiplying smoking attributable deaths by the present value of forgone lifetime earnings (PVLE) for each person at the age of death. The PVLE is estimated by rural/urban district, gender, and five-year age groups based on the approach developed by Max *et al*[20] which takes into account life expectancy for different gender and age subgroups, varying employment-population rates by rural/urban district, gender, and five-year age groups, and a discount rate of 3% to convert a stream of earnings into its current worth. To consider potential growth on future earnings, we assumed an annual productivity growth rate of 8%, approximately the average growth rate of gross domestic product (GDP) in China between 1998 and 2002. The employment-population rate was estimated from the 1998 NHSS data by dividing the number of currently employed persons by the total population. Definitions and calculation of earnings were the same as described above.

RESULTS

China had 1.243 billion people in 2000—427 million aged 35–64 years and 88 million aged 65+.[14] Among the 515 million people aged 35+, 323 million (63%) lived in rural areas and 192 million (37%) lived in urban areas. The prevalence of cigarette smoking in China is high. According to the 1998 NHSS data, 38% of the adults aged 35+ were ever smokers including 34.5% as current smokers and 3.5% as former smokers. The ever-smoking rates among men in the urban areas were 75.3% for ages 35–64 and 61.0% for ages 65+, lower than the corresponding rates in the rural areas of 84.8% and 73.4%, respectively. The smoking rates among women in urban areas were higher than those in rural areas for both age groups (6.1% and 14.8% versus 5.3% and 10.3%). The smoking rates for men were higher among ages 35–64 than among the older group; the opposite was found for women.

Based on our estimates of the smoking prevalence rates and the RRs estimated by Liu *et al*,[13] SAFs were calculated (table 1). The SAFs are substantially smaller for women than men, resulting from the much lower smoking prevalence among women. Cancer showed the highest disease-specific SAFs for men, while for women, respiratory diseases showed the highest SAFs. Note that the SAFs for rural female smokers were zero for cardiovascular diseases because the estimated RRs were less than one.[13]

Table 1 Smoking attributable fractions (SAFs) of mortality associated with smoking in China, 2000, by disease, urban/rural district, gender, and age

	SAF(%)			
	Male		Female	
Diseases	35–64	65+	35–64	65+
Urban				
Cancer	28.9	24.7	3.9	9.0
Cardiovascular diseases	10.0	8.3	0.8	2.0
Respiratory diseases	23.9	20.3	7.2	15.9
Rural				
Cancer	26.1	23.5	1.1	2.1
Cardiovascular diseases	9.4	8.2	0.0	0.0
Respiratory diseases	17.1	15.2	2.2	4.2

Table 2 shows the SAEs of inpatient hospitalisations, outpatient visits, and self-medications by disease category, rural/urban district, gender, and age. The total SAE amounted to $1705.7 million. Among the three disease categories, treating respiratory diseases cost the most for both urban smokers ($604.1 million) and rural smokers ($274.0 million)—$878.2 million, or 51% of the total SAE. The results from disaggregated analyses by types of health care services show similar patterns except that for inpatient hospitalisation, treating cancer cost the most for ages 35–64 for rural men and urban women and treating cardiovascular diseases cost the most for urban men aged 35–64, and that for self-medication, treating cardiovascular diseases cost the most for urban men aged 65+. The SAEs for treating cancer and cardiovascular diseases were $300.2 million (18%) and $527.3 million (31%), respectively. In general, the middle age group incurred higher SAEs than the older group.

China had 688 512 deaths attributed to smoking in 2000—599 723 for men and 88 789 for women; 248 808 in urban areas and 439 704 in rural areas—accounting for 8.3% of all deaths. Table 3 shows that the YPLLs for these smoking attributable deaths were estimated as 9.7 million years—8.6 million years for men and 1.1 million years for women; 3.4 million years for urban smokers and 6.3 million years for rural smokers. The disaggregated analyses by underlying causes of death show that older women had higher total smoking attributable YPLLs than the middle age women except for the deaths caused by cancer in rural areas. The opposite is true for men in that the middle age group had higher smoking attributable YPLLs than the older group except for the deaths caused by respiratory diseases in both urban and rural areas. The average years of life lost per death was 14.1 years—14.4 years for men and 12.2 years for women; 13.9 for urban smokers and 14.2 for rural smokers.

The estimated PVLEs for an average Chinese in 2000 by rural/urban district, gender, and age are shown in the Appendix. Table 4 shows the value of lost productivity caused by smoking-related deaths in 2000: $2935.5 million—$2816.3 million for men and $119.2 million for women; $790.4 million in urban areas and $2145.1 million in rural areas. The value of lost productivity averaged $4264 per death—$4696 for men and $1342 for women; $3177 for urban smokers and $4878 for rural smokers. The leading cause of smoking attributable mortality costs is cancer at $1903.1 million (65%), followed by respiratory diseases at $534.4 million (18%), and cardiovascular diseases at $498.0 million (17%).

Table 5 shows that the smoking attributable transportation and caregivers costs were $122.5 million, much smaller than

Table 2 Smoking attributable health care expenditures in China, 2000, by service type, disease, urban/rural district, gender, and age. Unit: US$1000

	Inpatient hospitalisations						Outpatient visits						Self-medication						
	Male			Female			Male			Female			Male			Female			
Diseases	**35–64**	**65+**	**Subtotal**	**35–64**	**65+**	**Subtotal**	**35–64**	**65+**	**Subtotal**	**35–64**	**65+**	**Subtotal**	**35–64**	**65+**	**Subtotal**	**35–64**	**65+**	**Subtotal**	**Total**
Urban																			
Cancer	61275	52339	113614	13834	8277	22111	37239	9156	46395	2398	2569	4968	4524	0	4524	23	0	23	191634
CV diseases	115158	74653	189810	5836	6076	11912	105406	69650	175056	9245	10982	20227	15880	11811	27691	2616	2845	5461	430158
Resp diseases	44350	96918	141268	9664	23181	32845	173116	80829	253944	49647	42382	92029	45222	10680	55902	18019	10114	28133	604123
Subtotal	220784	223909	444692	29334	37534	66868	315761	159635	475395	61291	55933	117224	65626	22491	88117	20658	12959	33617	1225915
Rural																			
Cancer	35600	12280	47880	1000	263	1263	49072	8892	57964	671	53	723	332	440	771	1	5	6	108608
CV diseases	24268	15291	39559	0	0	0	36391	16555	52945	0	0	0	3046	1600	4645	0	0	0	97149
Resp diseases	30131	18297	48429	3437	2284	5720	132524	34464	166988	17437	10272	27709	15538	5481	21019	2814	1356	4170	274035
Subtotal	89999	45868	135867	4436	2547	6983	217986	59911	277897	18108	10324	28432	18915	7520	26435	2815	1362	4177	479792
Total	310783	269777	580560	33771	40081	73851	533747	219545	753292	79399	66258	145656	84542	30011	114552	23473	14321	37794	1705707

Exchange rate of the Chinese Yuan against US$ =8.2784 based on China Statistical Yearbook, 2003, table 17-2.
CV, cardiovascular; Resp, respiratory.

the direct medical costs of smoking. Productivity losses due to absence from work caused by smoking-related illness amounted to $270.6 million. Total indirect morbidity costs of smoking in 2000 amounted to $393.0 million—$344.5 million for men and $48.5 million for women; $175.8 million in urban areas and $217.2 million in rural areas.

Table 5 also summarises the estimates for all the components of the economic burden of smoking. In 2000, the total economic cost of smoking in China was $5034.2 million. A larger share of the total economic cost was borne by men than women ($4609.2 million versus $425.0 million), and in rural areas than in urban areas ($2842.1 million versus $2192.1 million). Total annual economic losses averaged $25.43 per smoker among the 198 million smokers aged 35 and older in 2000—$31.46 for urban smokers and $22.16 for rural smokers. Given that China's cigarette consumption in 2000 was 30.76 million cases (that is, 76.9 billion packs),[21] the economic cost of smoking averaged $0.07 per pack.

Lost productivity caused by premature deaths accounted for the largest proportion of the total economic costs at $2935.5 million (58% of the total), followed by the direct costs at $1705.7 million (34%), and then indirect morbidity costs at $393.0 million (8%). Smoking attributable direct costs accounted for 3.1% of China's national health care expenditures in 2000 at $55.4 billion.[18] Outpatient visits accounted for the highest proportion of smoking attributable direct costs at $898.9 (53%), followed by inpatient hospitalisations at $654.4 (38%), and self-medication at $152.3 (9%).

DISCUSSION

The results of this study indicate that the adverse health effects of smoking cause a huge economic burden to the Chinese society, reaching $5034.2 million in 2000. Results also show that $1705.7 million, 3.1% of the national health care expenditures, were spent on treating smoking-related diseases.

Compared to Western countries such as the USA where smoking attributable direct costs accounted for 6–8% of national personal health care expenditures,[9] our estimates seem low. Our estimates are likely conservative for several reasons.

First, we used the RRs from a retrospective mortality study of one million deaths by Liu *et al*[13] and their estimates were much lower than those from Western countries. For example, the RRs of lung cancer among men aged 35 and older were 2.98 for urban smokers and 2.57 for rural smokers in China compared to 22.36 for current smokers and 9.36 for former smokers in the USA.[22] The RRs of coronary heart disease among men aged 35–64 were 1.28 for both urban and rural smokers in China versus 2.81 for current smokers and 1.75 for former smokers in the USA.[22]

Few studies have assessed the RRs of smoking for the Chinese population.[13 23–26] We chose the estimates by Liu *et al*[13] because their study was based on a large national sample and was the only study providing the RR estimates by gender and rural/urban district. In general, the RRs estimated by Liu *et al* were comparable to those from other Chinese prospective studies and case–control studies.[13] However, Lam *et al*[26] have argued that most studies on smoking-related mortality in China tend to underestimate the RRs of smoking because of the short follow-up. They demonstrated that as the duration of follow-up period increased, RRs also increased. Based on 20 years of follow-up, their estimated RRs were similar to those in the USA and the UK. We conducted a sensitivity analysis by using the RRs estimated by Lam *et al*[26] while keeping other data unchanged. The total economic costs of smoking more than doubled, from $5034 million to $12 151 million, and the proportion of smoking attributable direct

Table 3 Smoking attributable years of potential life lost (YPLL) in China, 2000, by disease, urban/rural district, gender, and age

	Male			Female			
Diseases	35–64	65+	Subtotal	35–64	65+	Subtotal	Total
Urban							
Cancer	1179329	568724	1748053	113417	152301	265718	2013770
CV diseases	322819	287313	610132	18205	78012	96217	706350
Resp diseases	167638	292788	460426	36876	228890	265766	726192
Subtotal	1669786	1148824	2818611	168498	459203	627701	3446312
Rural							
Cancer	2372443	816935	3189378	64682	51212	115894	3305273
CV diseases	583184	542704	1125888	0	0	0	1125888
Resp diseases	593305	892537	1485842	63760	272176	335936	1821778
Subtotal	3548933	2252176	5801109	128442	323388	451831	6252939
Total	5218720	3401000	8619720	296940	782592	1079532	9699251

CV, cardiovascular; Resp, respiratory.

costs to the national health expenditures increased to 7.7%, comparable to that in the USA.

Second, when estimating PVLE, we assumed earnings were the same for all subgroups by age and gender because of the data limitation. As shown in the Appendix, the PVLE is the highest for persons < 1 year and decreases with age. Max *et al*[20] found that the American males and females aged 20–24 have the highest PVLE at a discount rate of 3% given the varying earnings for each five-year age group. If the pattern of earnings by age in China is similar to that in the USA, our PVLE estimates may be overestimated for persons younger than age 20 and underestimated for persons ⩾ 20; therefore, our estimated indirect costs of smoking for persons aged 35 and older may be underestimated. Also, we assumed 8% as the annual growth rate in productivity that is lower than the average growth rate of GDP in China during 1979–2002 at 9.4%.[17] According to China's National Bureau of Statistics, the annual rates of GDP growth in 2003 and 2004 reached 10%. The estimated costs of smoking would be higher if the growth rate of 9.4% is assumed. However, if we assume the growth rate in China will be reduced to 5% beginning in 2006, the indirect mortality costs of smoking would be reduced from $2.9 billion to $2.2 billion.

Third, we estimated the smoking prevalence rates by using the 1998 NHSS data. Yang *et al*[27] estimated that the prevalence rate of ever-smokers for persons aged 15–69 was 66.9% for men and 4.2% for women using the 1996 National Prevalence Survey. Applying the same age criteria, the corresponding rate was 57.5% for men and 3.8% for women from the 1998 NHSS data. In other words, our estimate was about 15% lower for men and 10% lower for women than the estimates by Yang *et al*. This could be due to an underreporting of smoking status among respondents in the 1998 NHSS. We conducted another sensitivity analysis by increasing the smoking prevalence rate by 15% for each age group for men while keeping other things unchanged. The total economic costs of smoking increased by about 10%, from $5034 million to $5569 million.

Fourth, our calculation for the economic burden of smoking only considers the three major categories of smoking-related diseases. We did not include peptic ulcer diseases and liver cirrhosis, two diseases estimated to account for 14–19% of smoking attributable medical costs, YPLLs, and mortality costs according to two recent studies in Asia.[28 29] Additionally, Yang *et al*[29] found that kidney diseases caused the most smoking attributable medical costs. Further research is needed to examine the effects of smoking on the morbidity and mortality resulting from peptic ulcer, liver cirrhosis, and kidney diseases and their economic costs among the Chinese population.

Finally, we did not count the days lost from work by the relatives taking care of patients with smoking-related illness, the health care costs of environmental tobacco smoke, and the deaths resulting from cigarette-caused fires and passive smoking. For persons younger than age 35, passive smoking is the main risk for diseases such as bronchitis and low birth weight. Yang *et al*[1] estimated that more than 50% of Chinese non-smokers aged 15 and older were passive smokers in 2002. Therefore, the true economic burden of smoking in China could be much higher than the estimates in this study, which only focuses on the evaluation of active smoking.

Table 4 Smoking attributable costs of premature deaths in China, 2000, by disease, urban/rural district, gender, and age. Unit: US$1,000

	Male			Female			
Diseases	35–64	65+	Subtotal	35–64	65+	Subtotal	Total
Urban							
Cancer	497171	36383	533555	20448	3848	24297	557851
CV diseases	125219	17127	142346	2492	1601	4093	146439
Resp diseases	60351	16437	76788	5272	4057	9329	86117
Subtotal	682742	69947	752688	28213	9506	37719	790407
Rural							
Cancer	1161996	150866	1312862	26180	6190	32370	1345232
CV diseases	261264	90261	351525	0	0	0	351525
Resp diseases	254861	144372	399232	22319	26777	49096	448328
Subtotal	1678121	385499	2063620	48499	32967	81466	2145086
Total	2360862	455446	2816308	76712	42473	119185	2935493

Exchange rate of the Chinese Yuan against US$ = 8.2784 based on China Statistical Yearbook, 2003, table 17-2.
CV, cardiovascular; Resp, respiratory.

Table 5 Economic costs of smoking in China, 2000, among adults of age 35 and older. Unit: US$1000

Type of costs	Urban			Rural			Both areas		
	Male	Female	Subtotal	Male	Female	Subtotal	Male	Female	Total
Direct medical costs									
Inpatient	444692	66868	511561	135867	6983	142851	580560	73851	654411
Outpatient	475395	117224	592619	277897	28432	306329	753292	145656	898949
Self-medication	88117	33617	121735	26435	4177	30612	114552	37794	152347
Subtotal	1008205	217710	1225915	440199	39592	479792	1448404	257302	1705707
Indirect morbidity costs									
Transportation and caregivers	63690	14239	77929	41675	2860	44534	105365	17099	122464
Absence from work	86023	11867	97889	153118	19555	172674	239141	31422	270563
Subtotal	149713	26106	175819	194793	22415	217208	344506	48521	393027
Indirect mortality costs	752688	37719	790407	2063620	81466	2145086	2816308	119185	2935493
Total	1910606	281535	2192141	2698612	143473	2842085	4609218	425008	5034226

Exchange rate of the Chinese Yuan against US$ =8.2784 based on China Statistical Yearbook, 2003, table 17-2.

This study is based on the conventional epidemiological approach[6 7 29] which estimates the smoking attributable risks of mortality caused by the three major smoking-related diseases, and applies the attributable risks of mortality to the morbidity toll. In an alternative epidemiological approach,[8 28] the smoking attributable risks of healthcare utilisation for smoking-related diseases are estimated and applied to healthcare expenditures. Several recent studies in the USA have developed the econometric approach[10 30–32] which examines the relationship between smoking and healthcare expenditures in a multi-equation framework by adjusting other risk factors, health status, and individuals' taste for consuming health care. These econometric studies estimate smokers' total excess expenditures over those of non-smokers by including all types of diseases. Warner *et al*[9] anticipate that the econometric approach will become the norm in cost-of-smoking analyses. Due to the limitation of our data, neither the smoking attributable risks of healthcare utilisation nor the econometric models are estimated in this study.

In conclusion, our very conservatively estimated results suggest that cigarette smoking costs an enormous economic burden in China through a huge number of preventable diseases, health care costs, premature deaths, and productivity losses. The total economic costs had grown from $3.3 billion in 1989[5] to $5.0 billion in 2000. Since the health effects of smoking on morbidity and mortality are cumulative, China will bear a much heavier economic burden from cigarette smoking in the future if the current trends in smoking behaviour continue. The economic burden of smoking in the rural areas will be of special concern because of the large proportion of population, the high smoking prevalence rate, and poverty. To reduce the economic burden of smoking to the society, effective tobacco control programmes and sustained efforts are needed in China to curb the tobacco epidemic. We hope that the results of this study will motivate policymakers in China to formulate a comprehensive health and economic agenda with adequate investment in research, public education, health providers' training, and intervention programmes aimed at tobacco prevention and control.

What this paper adds

This paper provides an updated and comprehensive estimate of the economic costs of smoking in China. Our findings justify the need for stronger tobacco control policies in China.

ACKNOWLEDGEMENTS

This study was supported by a grant from the Fogarty International Center (grant R01-TW05938) National Institutes of Health. The authors are grateful for comments provided by Professors Ming-Chin Yang, Gregor A Franz, and Dorothy P Rice. However, the authors alone are responsible for the findings.

Authors' affiliations

H-Y Sung, Institute for Health & Aging, School of Nursing, University of California, San Francisco, California, USA
L Wang, S Jin, Y Jiang, National Center for Public Health Surveillance and Information Services, Chinese Center for Disease Control and Prevention, Beijing, China
T-W Hu, School of Public Health, University of California, Berkeley, California, USA

Competing interests: None

REFERENCES

1 **Yang GH**, Ma JM, Liu N, *et al*. Smoking and passive smoking in Chinese, 2002. *Zhonghua Liu Xing Bing Xue Za Zhi*. 2005;26: 77–83, [in Chinese].
2 **Jha P**, Chaloupka FJ. *Curbing the epidemic: governments and the economics of tobacco control*. Washington, DC: World Bank, 1999.
3 **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.
4 **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.
5 **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.
6 **Luce BR**, Schweitzer SO. Smoking and alcohol abuse: a comparison of their economic consequences. *N Engl J Med* 1978;**298**:569–71.
7 **Office of Technology Assessment, US Congress**. Smoking related deaths and financial costs. OTA staff memorandum. Washington, DC: Health Program, OTA, 1985.
8 **Rice DP**, Hodgson TA, Sinsheimer P, *et al*. The economic costs of the health effects of smoking, 1984. *Milbank Q* 1986;**64**:489–547.
9 **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.
10 **Max W**, Rice DP, Sung HY, *et al*. The economic burden of smoking in California. *Tob Control* 2004;**13**:264–7.
11 **Lilienfeld AM**, Lilienfeld DE. *Foundations of epidemiology*, 3rd ed. New York: Oxford University Press, 1994.
12 **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.
13 **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.
14 **National Bureau of Statistics, People's Republic of China**. *Tabulation on the 2000 Population Census of People's Republic of China*, China Statistics Press. National Bureau of Statistics, People's Republic of China.
15 **Ministry of Health, People's Republic of China**. *China Health Statistics Yearbook 2001*. Beijing: Ministry of Health, 2001:200–399.
16 **World Heath Organization**. Life tables for 191 countries, world mortality in 2000. WHO website: http://www.who.int/country/chn/en/ (Accessed 20 April 2004).
17 **National Bureau of Statistics, People's Republic of China**. *China Statistics Yearbook 2003*. Beijing: China Statistics Press, 2004.

18 **China National Health Economic Institute**. *China National Health Accounts Digest.* Beijing: China Statistics Press, 2004.
19 **Rice DP**, Cooper B. The economic value of human life. *Am J Public Health* 1967;**57**:1954–66.
20 **Max W**, Rice DP, Sung HY, *et al. Valuing human life: estimating the present value of lifetime earnings, 2000*, Center for Tobacco Control Research and Education, Economic Studies and Related Methods, October 1, 2004. http://repositories.cdlib.org/ctcre/esarm/PVLE2000.
21 **Liu T**, Xiong B. *Tobacco economy and tobacco control* [in Chinese]. Beijing: Economic Science Press, 2004.
22 **US Department of Health and Human Services**. *Reducing the health consequences of smoking: 25 years of progress. A report of the Surgeon General, 1989.* Rockville, Maryland: Public Health Service, Centers for Disease Control, Office on Smoking and Health, 1989, (DHHS Publication No (CDC) 89-8411.).
23 **Yuan JM**, Ross RK, Wang XL, *et al.* Morbidity and mortality in relation to cigarette smoking in Shanghai, China: a prospective male cohort study. *JAMA* 1996;**275**:1646–50.
24 **Chen ZM**, Xu Z, Collins R, *et al.* Early health effects of the emerging tobacco epidemic in China. A 16-year prospective study. *JAMA* 1997;**278**:1500–4.
25 **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.
26 **Lam TH**, He Y, Li LS, *et al.* Mortality attributable to cigarette smoking in China. *JAMA* 1997;**278**:1505–8.
27 **Yang G**, Fan L, Tan J, *et al.* Smoking in China: findings of the 1996 National Prevalence Survey. *JAMA* 1999;**282**:1247–53.
28 **Kang HY**, Kim HJ, Park TK, *et al.* Economic burden of smoking in Korea. *Tob Control* 2003;**12**:37–44.
29 **Yang MC**, Fann CY, Wen CP, *et al.* Smoking attributable medical expenditures, years of potential life lost, and the cost of premature death in Taiwan. *Tob Control* 2005;**14**(suppl I):i62–70.
30 **Bartlett JC**, Miller LS, Rice DP, *et al.* Medical expenditures attributable to cigarette smoking—United States, 1993. *MMWR Morb Mortal Wkly Rep* 1994;**43**:469–72.
31 **Miller LS**, Zhang X, Rice DP, *et al.* State estimates of total medical expenditures attributable to cigarette smoking, 1993. *Public Health Rep* 1998;**113**:447–58.
32 **Miller VP**, Ernst C, Collin F. Smoking-attributable medical care costs in the USA. *Soc Sci Med* 1999;**48**:375–91.

APPENDIX

Present value of lifetime earnings* in China, 2000, by urban/rural district, gender, and age. Unit: US$1

	Urban		Rural	
Age (years)	**Male**	**Female**	**Male**	**Female**
<1	238235	158620	189567	185462
1–4	218518	145609	173878	170249
5–9	177523	118246	141258	138256
10–14	140524	93525	111817	109351
15–19	110887	73636	88027	85974
20–24	85897	56320	68479	66757
25–29	64626	41330	52623	51202
30–34	47457	29258	40011	38830
35–39	33848	19679	30042	29042
40–44	23051	12136	22181	21315
45–49	14466	6669	16011	15249
50–54	8050	3361	11207	10543
55–59	3843	1718	7522	6979
60–64	1769	972	4842	4395
65–69	1014	575	2981	2649
70–74	632	335	1751	1548
75–79	382	174	1005	857
80–84	216	53	583	437
85+	96	0	288	168

Exchange rate of the Chinese Yuan against US$ = 8.2784 based on China Statistical Yearbook, 2003, table 17-2.
*Estimated by the authors with 3% discount rate and 8% productivity growth rate.