RESEARCH PAPER

Smoking attributable medical expenditures, years of potential life lost, and the cost of premature death in Taiwan

M C Yang, C Y Fann, C P Wen, T Y Cheng

Tobacco Control 2005;**14**(Suppl I):i62–i70. doi: 10.1136/tc.2004.007963

See end of article for authors' affiliations

Correspondence to: Ming-Chin Yang, Institute of Health Care Organization Administration, National Taiwan University, Taipei, Taiwan; mcy@ha.mc.ntu.edu.tw

Objective: To estimate the smoking attributable medical expenditures and productivity loss of people aged 35 and over in Taiwan in 2001 from a societal viewpoint.
Methods: A prevalence based approach was used to estimate smoking attributable costs. Epidemiological parameters were obtained from two follow up studies and government statistics. Data on medical care utilisation and expenditure were extracted from the National Health Insurance claim data.
Results: Total smoking attributable medical expenditures (SAEs) amounted to US$397.6 million, which accounted for 6.8% of the total medical expenditures for people aged 35 and over. Mean annual medical expenditures per smoker was US$70 more than that of each non-smoker. Smoking attributable years of potential life lost (YPLL) totalled to 217 761 years for males and 15 462 years for females, and the corresponding productivity loss was US$1371 million for males and US$18.7 million for females.
Conclusion: Medical expenditures attributable to smoking accounted for 6.8% of the total medical expenditure of people aged 35 and over for the year 2001 in Taiwan. Corresponding YPLL and productivity loss also demand that actions be taken to fight cigarette smoking.

Smoking is considered to be an important cause of premature mortality and disability. The World Health Organization estimated that annually smoking caused about four million deaths worldwide.[1] The US Centers for Disease Control and Prevention also reported that annually smoking caused approximately 444 000 premature deaths and cost $157 billion in health related economic losses in the USA between 1995 and 1999.[2]

Although numerous studies already reported the association between tobacco and disease and huge attributable expenditures, the association gained more attention due to recent tobacco settlements in the USA. To date, economic value of tobacco is still being debated between public health advocators and the tobacco industry.[3 4]

In Taiwan, health authorities have made controlling and preventing the adverse effects of smoking an important priority and enacted the Tobacco Hazards Control Act in 1997. During the policy formulation process, the authors conducted several studies to estimate smoking attributable expenditures (SAEs) in an attempt to provide evidence of the adverse effects of cigarette smoking. However, due to limited local data, certain parameters in our previous estimations were forced to use values reported in studies from other countries.

Fortunately, many of those data are now available after the implementation of the National Health Insurance (NHI) in 1995. Being a compulsory social insurance, more than 97% of the population were covered under this programme. The Bureau of NHI has released selected claims data for academic use since 2001. Therefore, types of services used and the medical expenditures can be determined from the datasets. In addition, epidemiological data were available by merging two cohort datasets—one was provided by Liaw *et al* (a community cohort)[5] and the other by Wen *et al* (a civil servant and teacher cohort).[6 7] A total of 86 580 persons were included in the final dataset. The mortality risks of current smokers compared to non-smokers were calculated based on Cox's proportional hazards model adjusted by age. Detailed descriptions of these studies and the relative risks (RR) were reported elsewhere.[7] Based on the information gathered from the above mentioned sources, we can estimate the SAEs more precisely.

The purpose of this study, therefore, was to estimate the SAEs in Taiwan in 2001 from a societal viewpoint. The results of this study could serve as a reference for health authorities when formulating tobacco control policies, and be used in health education programmes for the public.

METHODS

We used the prevalence based approach to estimate the burden of smoking on the society in 2001. Human capital approach was adopted as the theoretical basis to estimate cost of productivity caused by premature death. The method suggested by Rice *et al*[8] was used to estimate excess costs due to smoking in a year based on epidemiological findings.

Regarding the definition of smoking status, we followed the definitions used by Wen *et al*[7] that current smokers were those who were still smoking at the time of recruitment into the cohort study; non-smokers were those who never smoked; and ex-smokers were those who had quit smoking at least six months before the study.

In terms of parameters needed to estimate SAEs, we first estimated RRs of developing smoking related diseases between current smokers and non-smokers, followed by estimating the amount of medical care used and expenditures associated with each smoking related disease. The followings are detailed descriptions of how the parameters and costs were estimated in this study.

Estimating smoking attributable fraction (SAF)

We used smoking attributable fraction (also known as population attributable risk) to estimate the quantity of medical care attributable to smoking. This concept was first

Abbreviations: ICD-9, *International classification of diseases*, 9th revision; NHI, National Health Insurance; RR, relative risk; SAD, smoking attributable deaths; SAE, smoking attributable medical expenditure; SAMMEC II, smoking attributable mortality, morbidity, and economic costs software, release II; SAPDC, smoking attributable cost of premature deaths; SAYPLL, smoking attributable years of potential life lost; SFA, smoking attributable fraction; YPLL, years of potential life lost defined by Levin as the "maximum proportion of lung cancer attributable to cigarette smoking".[9] Subsequently, the concept was renamed as smoking attributable fraction (SAF) and used by Rice *et al*[8] and Shultz *et al*.[10] Below is the formula used to calculate SAF in this study:

$$SAF_{iys} = [P^0{}_{iys}+P^1{}_{iys}*RR^1{}_{iys} + P^2{}_{iys}*RR^2{}_{iys}-1]/[P0_{iys}+P1_{iys}*RR^1{}_{iys}+P^2{}_{iys}*RR^2{}_{iys}] \quad (1)$$

where P_0 is prevalence rate of non-smoking; P_1 is prevalence rate of current smoking; P_2 is prevalence rate of ex-smoking; RR_1 is relative mortality rate for current smokers compared to non-smokers; RR_2 is relative mortality rate for ex-smokers compared to non-smokers; y is age, categorised into three groups, 35-49, 50-64, and $\geqslant$ 65 years; and s is sex.

Prevalence rates of current smoking, ex-smoking, and non-smoking were obtained from the National Health Interview Survey of Taiwan in 2001.[11] Prevalence rates of current smoking for males aged 35–49 was 57.4%, 49.3 % for those aged 50–64, and 43.7% for those aged 65 and over. For females, those rates were 4.2%, 3.8 %, and 2.7% for the corresponding age groups. Prevalence rates of ex-smoking for males aged 35–49 was 6.2%, 9.0% for those aged 50–64, and 20.3% for those aged 65 and over. For females, those rates were 0.4%, 0.6 %, and 1.2%, respectively.

The RRs of current smokers compared to non-smokers for each disease by sex and age groups came from the combined cohort mentioned earlier.[5–7] Only those diseases with RR $>$ 1 (and $p < 0.05$) for current smokers compared to non-smokers were included in the study. These diseases were then grouped into 19 categories (table 1). In this study, because RRs of ex-smokers compared to non-smokers were not significant, the RRs of ex-smokers were set to 1 and the SAF of ex-smokers became zero.

Estimating the smoking attributable medical expenditures (SAEs)

The SAEs should include all the medical expenditures incurred due to smoking. However, this study included only outpatient and inpatient expenditures paid by the NHI. This is because the data released by the Bureau of NHI does not include the expenditures not covered by the insurance (for example, certain preventive services, and out-of-plan services).

To estimate the quantity and prices of medical care incurred, we used the *International classification of diseases*, 9th revision (ICD-9) codes of the 19 categories of diseases as the key variable to link NHI claim data. In terms of estimating morbidity costs, it would be ideal to use relative morbidity rate of smokers compare to non-smokers. However, since we did not have this data, we used relative mortality rate of each disease as the proxy. SAEs were calculated by the following formula:

$$SAE_{iys} = [P(MD)_{iys}\times Q(MD)_{iys}+P(H)_{iys}\times Q(H)_{iys}]\times SAF_{iys} \quad (2)$$

where P(MD) is the average expenditure per outpatient visit; Q(MD) is the number of outpatient visits; P(H) is the average expenditure per admission; Q(H) is the number of admissions; i is the type of disease; y is categorised into three age groups, 35-49, 50-64, and $\geqslant$ 65 years; and s is sex.

Estimating mean annual expenditure of current smokers and non-smokers

Because we did not have smokers or non-smokers' individual aggregated medical expenditures, we made some assumptions when estimating the mean medical expenditures for current smokers and non-smokers. The first assumption was that the basic needs for medical care are the same for current smokers and non-smokers. Thus, the total medical expenditure for current smokers will be the sum of SAE and the basic medical expenditures. The second assumption was that among all the risk factors affecting the use of medical services, smoking condition did not have significant interaction with other risk factors. Therefore, by subtracting SAE from the total medical expenditure, the remaining medical expenditure represents the "basic" expenditures for all the insured people regardless of their smoking condition. We can then determine the amount of this "basic" expenditure for current smokers simply by multiplying the total "basic" expenditure by the prevalence rate of current smoking. Thus mean medical expenditures for each current smoker and non-smoker can be estimated by the following formulae:

$$\text{Mean medical expenditures of current smokers} = [SAEs + (BasicExp \times P_1)]/(N\times P_1) \quad (3)$$

where SAEs is smoking attributable expenditures; BasicExp is total medical expenditure of the population SAEs; P_1 is prevalence rate of current smoking; and N is the number of total population.

$$\text{Mean medical expenditures of non-smokers} = (BasicExp \times P_0)/(N \times P_0) = BasicExp/N \quad (4)$$

where BasicExp is the total medical expenditure of the population SAEs; P_0 is prevalence rate of non-smoking; and N is the number of total population.

Estimating smoking attributable deaths, smoking attributable years of potential life lost (YPLL), and smoking attributable cost of premature death

Smoking attributable deaths were calculated through multiplying estimates of smoking attributable proportion of deaths by total mortality for adults aged 35 and over. However, deaths attributable to fire and exposure to second hand smoke that were accounted in SAMMEC II (smoking attributable mortality, morbidity, and economic costs software, release II) were not included in our study.[12]

Smoking attributable years of potential life lost (YPLL) were estimated according to age and sex specific life expectancy. Future earnings by sex and five year age groups was calculated based on 2001's official statistics related to labour force participation rates, unemployment rates, and the average annual income of those who were employed. Since the growth rates of both the average annual income and gross domestic product (GDP) from 1991 to 2000 happened to be the same at 6%, we used it as the annual increasing rate when estimating future earnings. When discounting future earnings, we used 3% as the discounting rate as suggested by Max *et al*.[12]

Smoking attributable deaths (SAD), smoking attributable YPLL (SAYPLL), and smoking- attributable cost of premature deaths (SAPDC) by sex, age group, and disease were estimated according to the following formulae:

$$SAD_{iys} = \Sigma[Q(D)_{iys}]\times SAF_{iys}$$
$$SAYPLL_{iys} = [\Sigma Q(D)_{igs} \times LE_{gs}]\times SAF_{iys}$$
$$SAPDC_{iys} = [\Sigma Q(D)_{igs} \times LE_{gs} \times PVFE_{gs}] \times SAF_{iys}$$

where i is type of diseases; y is categorised into three age groups, 35-49, 50-64, and $\geqslant$ 65; g is categorised into seven age groups, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64 and $\geqslant$ 65; s is sex; Q(D) is number of deaths; LE_{gs} is life expectancy, if died at age group g; and $PVFE_{gs}$ is present value of future earnings, if died at age group g, using a 3% discount rate and a 6% annual income growth rate.

Table 1 Relative risks (RRs) of mortality rate and smoking attributable fractions (SAFs) associated with smoking by disease, sex, and age group, 2001

		RR (95% CI)†				SAF					
						Male			Female		
Disease	ICD-9 code	Male 35+		Female 35+		35–49	50–64	65+	35–49	50–64	65+
Neoplasm of lip, oral cavity, pharynx	140–149	2.6	*(1.60 to 4.23)	–	–	0.46	0.42	0.36	–	–	–
Neoplasm of oesophagus	150	3.18	*(1.53 to 6.60)	15.57	*(1.23 to 197)	0.54	0.49	0.43	0.38	0.35	0.28
Neoplasm of stomach	151	1.68	*(1.16 to 2.43)	–	–	0.27	0.23	0.19	–	–	–
Neoplasm of rectum	154	2.06	*(1.01 to 4.18)	–	–	0.36	0.32	0.27	–	–	–
Neoplasm of liver, gallbladder, bile ducts	155–156	1.46	*(1.18 to 1.82)	5.03	*(2.36 to 10.7)	0.20	0.17	0.14	0.14	0.13	0.10
Neoplasm of trachea, lung, bronchus	162	2.73	*(2.08 to 3.59)	3.36	*(1.44 to 7.86)	0.48	0.44	0.38	0.09	0.08	0.06
Neoplasm of cervix, uteri	180	–	–	5.78	*(1.67 to 20.0)	–	–	–	0.17	0.15	0.11
Diabetes mellitus	250	1.51	*(1.13 to 2.02)	–	–	0.22	0.19	0.15	–	–	–
Rheumatic heart disease	390–398	–	–	9.43	*(1.09 to 81.5)	–	–	–	0.26	0.24	0.18
Ischaemic heart disease	410–414	2.06	*(1.51 to 2.81)	3.58	*(1.09 to 11.8)	0.36	0.32	0.27	0.10	0.09	0.06
Cardiac arrest and other heart disease	420–429	1.6	*(1.20 to 2.12)	–	–	0.24	0.21	0.17	–	–	–
Cerebrovascular disease	430–438	1.65	*(1.33 to 2.05)	–	–	0.26	0.23	0.18	–	–	–
Chronic bronchitis	491	3.13	*(1.05 to 9.29)	–	–	0.53	0.49	0.43	–	–	–
Asthma	493	–	–	7.12	*(1.89 to 26.9)	–	–	–	0.20	0.19	0.14
Chronic airways obstruction	496	2.65	*(1.54 to 4.56)	–	–	0.47	0.43	0.36	–	–	–
Peptic ulcer and GI haemorrhage	531–533	3	*(1.32 to 6.82)	22.28	*(3.36 to 148)	0.52	0.47	0.41	0.47	0.44	0.36
Liver cirrhosis	571	2.01	*(1.45 to 2.77)	–	–	0.35	0.31	0.26	–	–	–
Kidney diseases	580–589	2.23	*(1.44 to 3.47)	–	–	0.40	0.36	0.30	–	–	–
Accidents	E800–949	1.66	*(1.36 to 2.02)	–	–	0.26	0.23	0.19	–	–	–

*$p<0.05$.
†Cause specific relative risks (RRs) of mortality for current smokers compared with non-smokers (adjusted by age).
GI, gastrointestinal.

Table 2 Smoking attributable medical expenditures (SAEs) by disease, sex, and age group, 2001. Unit: US$1000

		Male				Female				
Disease	**ICD-9 code**	**35–49**	**50–64**	**65+**	**Subtotal**	**35–49**	**50–64**	**65+**	**Subtotal**	**Total**
Neoplasm of lip, oral cavity, pharynx	140–149	9040	6641	3771	19452	–	–	–	–	19452
Neoplasm of oesophagus	150	1300	2962	1933	6195	42	102	117	261	6456
Neoplasm of stomach	151	499	765	2620	3884	–	–	–	–	3884
Neoplasm of rectum	154	495	1485	3329	5309	–	–	–	–	5309
Neoplasm of liver, gallbladder, bile ducts	155–156	1511	2621	2877	7009	189	999	949	2137	9146
Neoplasm of trachea, lung, bronchus	162	1182	3801	10011	14994	258	542	623	1424	16418
Neoplasm of cervix, uteri	180	–	–	–	–	1534	1478	724	3736	3736
Diabetes mellitus	250	4051	7904	8529	20484	–	–	–	–	20484
Rheumatic heart disease	390–398	–	–	–	–	421	692	667	1780	1780
Ischaemic heart disease	410–414	5618	15513	24574	45704	392	1812	3281	5485	51189
Cardiac arrest and other heart disease	420–429	1708	2718	6378	10804	–	–	–	–	10804
Cerebrovascular disease	430–438	4012	8790	15686	28488	–	–	–	–	28488
Chronic bronchitis	491	839	1702	8068	10609	–	–	–	–	10609
Asthma	493	–	–	–	–	707	1003	1392	3102	3102
Chronic airways obstruction	496	327	1575	11802	13704	–	–	–	–	13704
Peptic ulcer and GI haemorrhage	531–533	9799	8923	13707	32428	5571	6435	7299	19305	51734
Liver cirrhosis	571	9030	6261	3167	18457	–	–	–	–	18457
Kidney diseases	580–589	23670	33373	27565	84608	–	–	–	–	84608
Accidents	E800–949	17949	9922	10403	38274	–	–	–	–	38274
Subtotal		91030	114954	154418	360402	9114	13063	15052	37230	397632
Percentage to total		12.19%	13.72%	10.67%	11.89%	1.16%	1.51%	1.26%	1.31%	6.76%
Total*		746597	838127	1446849	3031572	788294	867141	1193034	2848469	5880041

*Total, medical expenditures of all diseases by sex and age group for the insured persons aged 35 and over.

Table 3 Smoking attributable medical expenditures (SAEs) by disease, service type, and age group, 2001. Unit: US$1000

Disease	ICD-9 code	Outpatient 35–49	Outpatient 50–64	Outpatient 65+	Outpatient Subtotal	Inpatient 35–49	Inpatient 50–64	Inpatient 65+	Inpatient Subtotal
Neoplasm of lip, oral cavity, pharynx	140–149	4119	2235	2155	8510	4921	4406	1616	10942
Neoplasm of oesophagus	150	122	1141	233	1496	1221	1923	1816	4960
Neoplasm of stomach	151	198	185	686	1069	301	580	1933	2815
Neoplasm of rectum	154	108	599	1648	2355	387	887	1681	2954
Neoplasm of liver, gallbladder, bile ducts	155–156	289	898	1073	2259	1412	2723	2753	6887
Neoplasm of trachea, lung, bronchus	162	483	1626	3845	5953	958	2717	6790	10465
Neoplasm of cervix, uteri	180	933	926	369	2229	601	551	355	1507
Diabetes mellitus	250	3307	6649	6858	16813	744	1255	1671	3670
Rheumatic heart disease	390–398	116	288	254	657	305	404	413	1123
Ischaemic heart disease	410–414	1926	5741	9629	17296	4084	11584	18225	33893
Cardiac arrest and other heart disease	420–429	702	1203	2673	4578	1006	1515	3705	6226
Cerebrovascular disease	430–438	1679	4440	7645	13764	2333	4350	8042	14724
Chronic bronchitis	491	731	1204	3438	5374	108	497	4630	5235
Asthma	493	555	693	620	1868	152	310	772	1234
Chronic airways obstruction	496	197	776	3982	4955	130	798	7820	8748
Peptic ulcer and GI haemorrhage	531–533	12227	11254	10758	34238	3142	4105	10248	17495
Liver cirrhosis	571	5072	3597	1817	10485	3958	2664	1349	7972
Kidney diseases	580–589	22710	31922	24531	79163	960	1450	3034	5445
Accidents	E800–949	7736	4143	3319	15198	10213	5779	7084	23076
Subtotal		63209	79520	85532	228261	36936	48497	83937	169371
Percentage to total		5.96%	6.86%	5.77%	6.16%	7.80%	8.87%	7.26%	7.78%
Total*		1061280	1158349	1483350	3702979	473611	546918	1156533	2177062

*Total, medical expenditure of all diseases for the insured aged 35 and over, by age group and service type.

RESULTS

Table 1 shows the SAFs of smoking related diseases by sex and age groups. The disease SAFs for males, regardless of age group, were all over 50% in neoplasm of the oesophagus, chronic bronchitis, and peptic ulcer and gastrointestinal (GI) haemorrhage. On the contrary most SAFs for females were lower than 20%, except for neoplasm of the oesophagus, rheumatic heart disease, asthma, and peptic ulcer and GI haemorrhage. This is because the SAFs were determined by prevalence rate of smoking and RR of each disease. The relatively lower prevalence rate of smoking in females resulted in lower SAFs.

Table 2 shows the SAEs of each disease by sex and age group. Totally, the SAE of smokers was US$397.6 million, which accounted for 6.8% of the total medical expenditures of the NHI. The expenditure for kidney disease cost the most, which amounted to US$84.6 million, followed by peptic ulcer and GI haemorrhage (US$51.7 million), rheumatic heart disease (US$51.2 million), accidents (US$38.3 million), cerebrovascular disease (US$28.5 million), neoplasm of the lip, oral cavity and pharynx (US$19.5 million), and liver cirrhosis (US$18.5 million). When aggregating those seven types of neoplasm into one group, the SAE of neoplasm amounted to US$64.4 million, accounting for the second largest part of all SAEs.

In terms of the percentages of SAEs in the total amount of medical expenditures paid by the NHI, it was 11.9% for males and 1.3% for females. Among males, the percentage of SAEs for persons aged 50-64 was the highest. As for females, persons aged $\geqslant$ 65 had the highest percentage.

Table 3 shows the total SAEs of both outpatient and inpatient expenditures by disease. Outpatient expenditures were slightly higher than inpatient expenditures (US$228.3 million *v* $169.4 million). The percentage of SAEs in the total outpatient expenditure was slightly lower than that of the inpatient expenditure (6.2% *v* 7.8%). Most of the smoking attributable outpatient expenditures were spent on kidney diseases, especially on haemodialysis. On the other hand, ischaemic heart disease accounted for the highest amount for inpatient services.

Table 4 shows mean annual medical expenditure for current smokers and non-smokers. The mean annual medical expenditures for males were higher for current smokers than that of non-smokers across all age groups. Male current smokers aged 65 years and over had the highest expenditures. For current smokers in this group, outpatient expenditure was US$908 per person per year and inpatient expenditures was US$809, yielding a total expenditure of US$1717 per year. The corresponding amount for non-smokers was US$1278. Thus, on the average a current

Table 4 Mean annual medical expenditure of current smokers and non-smokers, 2001. Unit: US$

	Male 35–49	Male 50–64	Male 65+	Male Subtotal	Female 35–49	Female 50–64	Female 65+	Female Subtotal	Total
Outpatient									
Current smoker	203	454	907	370.97	277	605	1028	469.02	378.17
Non-smoker	163	338	684	324.98	215	441	751	380.17	252.11
Inpatient									
Current smoker	110	268	809	253.22	100	249	824	238.14	363.09
Non-smoker	85	195	594	225.40	80	166	503	184.40	197.08
Total									
Current smoker	312	721	1717	624.19	377	854	1852	707.16	630.29
Non-smoker	248	533	1278	550.38	295	607	1254	564.57	560.18
Difference	64	189	439	73.81	82	247	598	142.59	70.11

Table 5 Smoking attributable years of potential life lost (YPLL) by disease, sex, and age group, 2001. Unit: US$1000

		Male				Female				
Disease	**ICD-9 code**	**35–49**	**50–64**	**65+**	**Subtotal**	**35–49**	**50–64**	**65+**	**Subtotal**	**Total**
Neoplasm of lip, oral cavity, pharynx	140–149	11387	7187	2232	20806	–	–	–	–	20806
Neoplasm of oesophagus	150	3019	3430	2076	8524	44	160	197	401	8925
Neoplasm of stomach	151	1108	1294	2642	5045	–	–	–	–	5045
Neoplasm of rectum	154	703	1098	1344	3145	–	–	–	–	3145
Neoplasm of liver, gallbladder, bile ducts	155–156	6010	6471	3759	16241	720	1720	1687	4126	20368
Neoplasm of trachea, lung, bronchus	162	4422	8089	14170	26681	669	1043	909	2621	29302
Neoplasm of cervix, uteri	180	–	–	–	–	1279	915	623	2817	2817
Diabetes mellitus	250	2088	4018	4966	11072	–	–	–	–	11072
Rheumatic heart disease	390–398	–	–	–	–	90	136	200	425	425
Ischaemic heart disease	410–414	3535	4906	8677	17118	233	536	1443	2211	19329
Cardiac arrest and other heart disease	420–429	2427	2031	3452	7910	–	–	–	–	7910
Cerebrovascular disease	430–438	5057	6571	11310	22938	–	–	–	–	22938
Chronic bronchitis	491	33	77	557	666	–	–	–	–	666
Asthma	493	–	–	–	–	257	289	535	1081	1081
Chronic airways obstruction	496	312	1035	9590	10936	–	–	–	–	10936
Peptic ulcer and GI haemorrhage	531–533	641	659	2187	3487	124	393	1262	1779	5266
Liver cirrhosis	571	16887	8323	3097	28307	–	–	–	–	28307
Kidney diseases	580–589	1557	2454	5407	9419	–	–	–	–	9419
Accidents	E800–949	15346	6581	3539	25467	–	–	–	–	25467
Subtotal		74532	64225	79005	217761	3414	5192	6855	15462	233223
Percentage to total		21.2%	19.8%	15.0%	18.1%	2.3%	2.8%	1.6%	2.0%	11.9%
Total*		350967	324328	526014	1201310	151183	187429	417543	756155	1957465

*Total, YPLL of all diseases for aged 35 and over, by sex and age group

Table 6 Smoking attributable cost of premature death by disease, sex and age group, 2001. Unit: US$1000

		Male				Female				
Disease	ICD-9 code	35–49	50–64	65+	Subtotal	35–49	50–64	65+	Subtotal	Total
Neoplasm of lip, oral cavity, pharynx	140–149	131803	43950	3518	179271	–	–	–	–	179271
Neoplasm of oesophagus	150	32644	19615	3272	55531	141	200	53	394	55925
Neoplasm of stomach	151	12629	7134	4165	23928	–	–	–	–	23928
Neoplasm of rectum	154	8027	5800	2118	15946	–	–	–	–	15946
Neoplasm of liver, gallbladder, bile ducts	155–156	69326	36380	5925	111632	2345	1775	450	4570	116202
Neoplasm of trachea, lung, bronchus	162	50566	41563	22334	114464	2162	1216	242	3621	118084
Neoplasm of cervix, uteri	180	–	–	–	–	4277	1108	166	5551	5551
Diabetes mellitus	250	23456	21514	7827	52798	–	–	–	–	52798
Rheumatic heart disease	390–398	–	–	–	–	284	135	53	473	473
Ischaemic heart disease	410–414	40124	25982	13677	79783	750	553	385	1688	81471
Cardiac arrest and other heart disease	420–429	28782	11412	5440	45635	–	–	–	–	45635
Cerebrovascular disease	430–438	57605	35899	37793	131297	–	–	–	–	131297
Chronic bronchitis	491	327	312	877	1517	–	–	–	–	1517
Asthma	493	–	–	–	–	868	324	143	1335	1335
Chronic airways obstruction	496	3429	5004	15115	23548	–	–	–	–	23548
Peptic ulcer and GI haemorrhage	531–533	7449	3334	3447	14230	377	422	337	1135	15365
Liver cirrhosis	571	198735	50257	4882	253873	–	–	–	–	253873
Kidney diseases	580–589	17829	12845	8523	39197	–	–	–	–	39197
Accidents	E800-949	184834	38589	5579	229002	–	–	–	–	229002
Subtotal		867568	359590	144492	1371650	11205	5733	1828	18766	1390416
Percentage to total		21.08%	19.80%	17.43%	20.28%	2.20%	2.76%	1.64%	2.26%	18.32%
Total*		4116493	1816404	829098	6761995	509584	207889	111313	828786	7590781

*Total, premature cost of all diseases for aged 35 and over, by sex and age group using 3% discount rate.

Table 7 Summary table of total smoking attributable cost by sex and age group, 2001. Unit: US$1000

	Male				**Female**				
Type of cost	**35–49**	**50–64**	**65+**	**Subtotal**	**35–49**	**50–64**	**65+**	**Subtotal**	**Total**
Smoking attributable medical expenditures									
Outpatient	56272	70856	78569	205696	6937	8664	6964	22564	228261
Inpatient	34758	44098	75849	154705	2178	4400	8088	14666	169371
Subtotal	91030	114954	154418	360402	9114	13063	15052	37230	397632
Smoking attributable cost of premature death									
	867568	359590	144492	1371650	11205	5733	1828	18766	1390416
Total	958598	474544	298910	1732052	20320	18797	16879	55996	1788048

smoker aged 65 years or over spent US$439 ($1717 *v* $1278) more than a non-smoker in the same age group. Similarly, females in the same age group had the highest mean annual medical expenditures. A current smoker in this group spent US$1852 a year while a non-smoker spent US$1254. Thus, on the average, a female smoker aged 65 or over spent US$598 more ($1852 *v* $1254) than a non-smoker in the same age group.

Table 5 shows smoking attributable years of potential life lost (SAYPLL). It was 217 761 for males and 15 462 for females, and accounted for 18% of males' YPLL and 12% of females' YPLL due to all causes of death in 2001. All SAYPLL due to seven types of neoplasm amounted to 80 441 for males and 9965 for females, and accounted for 37% and 64% of total SAYPLL for males and females, respectively. Both for males and females, the SAYPLL due to liver cirrhosis and neoplasm of the trachea, lung, and bronchus were the two highest. Because of the high mortality rate in the oldest age group, it is reasonable to see that this age group had the highest SAYPLL. However, we need to pay more attention to the prevention of deaths from smoking related diseases for males in the younger age group of 35–49 years, because their SAYPLL ranked the second. When examined closely, we found that about 60% of the SAYPLL in this subgroup was due to three types of diseases, namely liver cirrhosis, accident, and neoplasm of the lip, oral cavity and pharynx.

Table 6 shows the smoking attributable cost of premature death. The total amount of smoking attributable cost of premature death was US$1371 million for males and US$18.8 million for females. For both males and females, age group 35–49 ranked the highest, followed by aged 50–64, and aged $\geqslant$ 65 ranked the last. Because of higher SAYPLL and higher labour force participation rates, it is not surprising that the younger male group accounted for much of the cost. Although we neglected the income from the underground economy and opportunity cost of housekeeping would underestimate the cost of premature death for females, it is not a major problem in this study because most of the SAFs for females are zero or trivial.

Table 7 summarises the results of this study. The total smoking attributable cost was US$1.79 billion in 2001 in Taiwan. In terms of type of cost, smoking attributable cost of premature death accounted for a very large proportion. As for sex, males accounted for the most part of the cost due to a much higher rate of smoking. With respect to age groups, younger group had lower medical expenditures, but higher cost of premature death.

DISCUSSION

Compared to our earlier estimations on SAEs in Taiwan, this study represents a major improvement in two ways. First, the RR of current smokers versus non-smokers was provided by a large combined cohort study that provided comprehensive smoking exposure and mortality data. Second, the amount of medical care utilised by each type of disease and their corresponding expenditures came from the NHI claim files. These claims represented the utilisation of about 97% of the total population. Therefore the current estimation of SAEs was more precise.

In terms of approaches used to estimate the cost of smoking, Warner *et al*[13] suggests that there are two major types in recent years. One is based on epidemiological findings, using attributable risks as the link between smoking attributable diseases and smoking attributable impacts, such as deaths and medical expenditures. Another approach is to directly collect smokers' and non-smokers' mortality and medical utilisation data. This study adopted the former approach due to limited data and time.

However, both of these approaches have been used in studies in Asia. For example, in Japan, Izumi *et al*[14] used a large population based cohort to collect smoking habit and medical utilisation data. They found that smokers consumed excess medical care. Our study had similar findings.

In South Korea, Kang *et al*[15] used both approaches in estimating the economic burden of smoking in South Korea. They found that current smokers spent a lot less direct medical costs than non-smokers according to the all causes approach. In our study, however, we found that current smokers had higher medical costs then non-smokers.

This study also adopted the suggestions made by Kang *et al*[15] that the cumulated effects of smoking on mortality may not appear in people under 35 years old. Thus we did not estimate the SAEs of people under 35.

With respect to the results in our study, kidney diseases accounted for 29% of outpatient expenditures for all diseases in males. Since 80% of renal dialyses were done in institution based haemodialysis centres in Taiwan, it will affect the productivity and quality of life of the patients. Thus, kidney disease should be the main concern when discussing the cost of smoking.

In terms of the percentage of SAEs in total medical expenditure, it was 6.8% in our study, which was similar to the USA.[2] However, Warner *et al*[13] suggested that 6–8% would be an underestimation of the true total medical costs of smoking in the USA. In addition, Zhang *et al*[16] reported that the SAEs of Medicare beneficiaries accounted for 11.4% of hospital care and 5.6% of ambulatory care in Medicare expenditures. In our study, for the corresponding older age group, smoking accounted for 7.3% of inpatient expenditures and 5.8% of outpatient expenditures. The percentages for ambulatory care were quite similar, but the percentage for hospital care was 4% lower in our study than in the USA. The difference might be due to higher unit price of hospital care in the USA.

Most smoking attributable YPLL were related to lung cancer, ischaemic heart disease, and chronic airway obstruction in the USA during 1995–1999.[2] In our study, the smoking attributable YPLL for lung cancer and ischaemic

What this paper adds

Taiwanese smokers incur excess medical expenditure, amounting to 6.8% for those aged 35 and over. As National Health Insurance is paid for by the general public, non-smokers in Taiwan share that excess medical expenditure. Each smoker spent an extra US$70 per year on medical care. Each year Taiwan lost an equivalent of US$1.4 billion in earning power of smokers, amounting to 0.5% of gross domestic product.

heart disease were also high, but the highest diseases were liver cirrhosis and neoplasm of the trachea, lung, and bronchus. Therefore, we should pay more attention to diseases of the liver when discussing the adverse effects of smoking.

We also noticed that some diseases showed much higher RRs of mortality rate in Lam's[17 18] study than those in our study. These diseases included lung cancer, oesophageal cancer, and chronic obstructive pulmonary disease for males. It may be because Lam used the RRs of patients who had smoked at any point in their lives compared with those who never smoked, while we compared current smokers with those who never smoked.

Finally, there were two limitations in this study. First, due to limited data, we were unable to estimate expenditures caused by passive smoking or expenditures not covered by the NHI, making it possible that the SAEs were underestimated.

Second, the RR of mortality was used to estimate the RR of morbidity for each disease. By doing so, we might underestimate some of the expenditures for patients in the more severe stages of disease or in patients with long term nonfatal sickness, such as the common cold. On the other hand, for fatal diseases, we might overestimate current smokers' SAEs. We used a simple formula to illustrate the relationship between RR of mortality and RR of morbidity.

Let D, I, and E denote death, incidence and exposure of a fatal disease.

RR of mortality =

$$\frac{P(D|E)}{P(D|\bar{E})} = \frac{P(D|I,E)^{*}P(I|E) + P(D|\bar{I},E)^{*}P(\bar{I}|E)}{P(D|I,\bar{E})^{*}P(I|\bar{E}) + P(D|I,\bar{E})^{*}P(I|\bar{E})}$$

When $P(D|\bar{I},E) = 0$, $P(D|\bar{I},\bar{E}) = 0$, and $P(I|E)/P(I|\bar{E}) =$ RR of morbidity.

We get the result that RR of mortality = $\frac{P(D|I,E)}{P(D|I,\bar{E})}$*RR of morbidity.

In this case, the value of $\frac{P(D|I,E)}{P(D|I,\bar{E})}$ will determine whether using RR of mortality as the proxy of RR of morbidity was biased. Because patients with smoking habit are considered to have poor recovery,[13] the ratio seems to be greater than 1. However, the absolute value of the ratio will be hard to estimate. In addition, the existence of co-morbidity would complicate this question. Future study may consider to break down the natural history of disease to estimate the difference of transient rate in each state between smokers and non-smokers.

Due to the limitations mentioned above, caution should be taken when using the results of this study.

ACKNOWLEDGEMENTS

The authors wish to thank the National Health Research Institute for providing National Health Insurance claims data. We would also like to thank Dr Chien-Jen Chen for providing the community cohort data.

Authors' affiliations

M C Yang, C Y Fann, Institute of Health Care Organization Administration, National Taiwan University, Taipei, Taiwan

C P Wen, T Y Cheng, Division of Health Policy Research, National Health Research Institutes, Taipei, Taiwan

Competing interests: none declared

REFERENCES

1 **World Health Organization**. The World Health Report 1999. Chapter 5. *Combating the Tobacco Epidemic* 1999:65–79.
2 **Centers for Disease Control and Prevention**. Annual smoking– attributable mortality, years of potential life lost, and economic costs – United States, 1995–1999. *MMWR Morb Mortal Wkly Rep* 2002;**51**:300–3.
3 **Cutler DM**, Gruber J, Hartman RS, *et al*. The economic impacts of the tobacco settlement. *Journal of Policy Analysis and Management* 2002;**21**:1–19.
4 **Warner KE**. The economics of tobacco: myths and realities. *Tobacco Control* 2000;**9**:78–89.
5 **Liaw KM**, Chen CJ. Mortality attributable to cigarette smoking in Taiwan, a 12-year follow up study. *Tobacco Control* 1998;**7**:141–8.
6 **Ho MS**. *A long-term follow-up study of chronic diseases among civil servant and teachers in Taiwan. The Project Report.* Taiwan: Institute of Biomedical Sciences, Academia Sinica, 1993.
7 **Wen CP**, Tsai SP, Chen CJ, *et al*. The mortality risk of smokers in Taiwan. Part I: cause-specific mortality. *Prev Med* 2004;**39**:528–35.
8 **Rice DP**, Hodgson TA, Sinsheimer P, *et al*. The economic costs of the health effects of smoking, 1984. *The Milbank Quarterly* 1986;**64**:489–547.
9 **Lilienfeld AM**, Lilienfeld DE. *Foundations of epidemiology*, 3rd ed. New York: Oxford University Press, 1994.
10 **Shultz JM**, Novotny TE, Rice DP. Quantifying the disease impact of cigarette smoking with SAMMEC II software. *Public Health Reports* 1991;**106**:326–33.
11 National Health Interview Survey (NHIS) in 2001. Bureau of Health Promotion and National Health Research Institutes, 2002. http://nhis.nhri.org.tw.
12 **Max W**, Rice DP, Sung HY, *et al*. Valuing human life: estimating the present value of lifetime earning, 2000. http://repositories.cdlib.org/ctcre/esarm/PVLE2000.
13 **Warner KE**, Hodgson TA, Carroll CE. Medical costs of smoking in the United States: estimates, their validity, and their implications. *Tobacco Control* 1999;**8**:290–300.
14 **Izumi Y**, Tsuji I, Ohkubo T, *et al*. Impact of smoking habit on medical care use and its costs: a prospective observation of National Health Insurance beneficiaries in Japan. *Int J Epidemiol* 2001;**30**:616–21.
15 **Kang HY**, Kim HJ, Park TK, *et al*. Economic burden of smoking in Korea. *Tobacco Control* 2003;**12**:37–44.
16 **Zhang X**, Miller L, Max W, *et al*. Cost of smoking to the Medicare Program, 1993. *Health Care Financing Review* 1999;**20**:179–96.
17 **Lam TH**, Ho SY, Hedley AJ, *et al*. Mortality and smoking in Hong Kong: case-control study of all adult deaths in 1998. *BMJ* 2001;**323**:361.
18 **Lam TH**, He YP, Li LS, *et al*. Mortality attributable to cigarette smoking in China. *JAMA* 1997;**278**:1505–8.