Lifetime medical expenditure and life expectancy lost attributable to smoking through major smoking related diseases in Taiwan

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RESEARCH PAPER

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Objective: To estimate the lifetime financial burden on Taiwan's national health insurance (NHI) system, life expectancy and years of life expectancy lost (YLEL) attributable to smoking from major smoking related diseases.
Methods: 10 major smoking related diseases (seven cancers, stroke, acute myocardial infarction and chronic obstructive pulmonary disease) were selected for this study. A survival analysis was conducted on linked cohorts from the National Death Registry database and the National Cancer Registry (NCR) and patients at the National Taiwan University Hospital (NTUH). Estimation of the smoking attributable fraction (SAF) for the study diseases was undertaken by combining the relative risks of smokers against non-smokers and the prevalence of smoking in Taiwan. The YLEL attributable to smoking was calculated for the study diseases by combining the survival analysis results, the SAF and the annual incidences of each disease. The lifetime medical expenditure for the study diseases was estimated by integrating the survival curve and the mean annual medical costs calculated from NHI reimbursement records.
Results: There were 241 280 incidents of the 10 study diseases in 2001, of which about 53 648 cases (22.2%) were attributable to smoking, with a total YLEL of 191 313 at an average of about 3.6 YLEL per case. For each case, the average survival time was about 10.2 years. Under two different annual discount rates, the total lifetime financial burden on the NHI was estimated at between $291 million (£147 million; €216 million) (3% discount) and $336 million (1% discount) for all diseases attributable to smoking in 2001, accounting for about 24.6% of the total estimated lifetime medical expenditure for all incidents of the 10 study diseases.
Conclusions: Smoking places tremendous financial and health burdens upon both society and individuals. A much more stringent tobacco control strategy is needed to curb the damage from smoking.

Smoking causes many fatal and non-fatal diseases, imposing both health and financial burdens on individuals and the society as a whole.[1] Ideally, effective assessment of the health burden and medical costs caused by smoking can be undertaken by direct comparison of the long term health outcomes and medical costs for both smokers and non-smokers. A 30-month prospective cohort study in a rural Japanese community of National Insurance beneficiaries, found that about 4% of total medical costs were attributable to smoking for the population aged 45 years and over.[2] Given the lack of long term prospective cohorts, the majority of previous studies estimate the smoking attributable fraction (SAF) from reliable epidemiological studies, and then use SAF and information on medical costs to calculate the financial burden attributable to smoking. Their results show that the medical costs of smoking among adults account for about 6–14% of personal healthcare expenditures in most countries.[3–6]

Such studies generally estimate the annual medical costs attributable to smoking. To our limited knowledge, projection of the potential lifetime medical costs and quantification of loss of life expectancy, as well as chronic morbidity attributable to smoking, has yet to be undertaken. To accomplish the above goals, we selected 10 major smoking related diseases as examples to quantify the impact of smoking.

METHODS

Smokers have markedly increased risks of multiple cancers, heart disease, strokes, emphysema and other diseases.[1] Wen *et al* reported the relative mortality risks for various smoking related diseases in Taiwan,[7] which provide an empirical basis to further explore the burden of major smoking related diseases on the years of life expectancy lost (YLEL) and medical costs attributable to smoking.

We considered 10 diseases for this study: cancers of the lips, oral cavity and pharynx, cancer of the oesophagus, stomach cancer, cancer of the rectum, liver/gallbladder cancer, lung cancer, cancer of the cervix/uterus, stroke, acute myocardial infarction (AMI) and chronic obstructive pulmonary disease (COPD). We calculated the YLEL (compared with the life expectancy of the general population) and the lifetime medical costs for patients with these diseases.

We hypothesise that both the YLEL and lifetime medical costs attributable to smoking can be determined by taking the SAF into account. Given the small number of smoking related deaths among young people and the protracted latency periods of most of the diseases, patients below 35 years of age were excluded from our calculation of the mortality risks for smokers.[7] Therefore, in this study, the survival analysis and estimations of the medical costs includes incidents of the 10 disease involving only those patients aged≥35 years.

Study cohorts and survival analysis

The study populations for the cancers under examination were obtained from the National Cancer Registry (NCR) in Taiwan between 1991 and 2000, which were verified to be about 80.7% comprehensive for all cancer cases.[8] The stroke cohorts for

Abbreviations: AMI, acute myocardial infarction; COPD, chronic obstructive pulmonary disease; NCR, National Cancer Registry; NHI, national health insurance; NTUH, National Taiwan University Hospital; QALY, quality adjusted life years; QOL, quality of life; SAF, smoking attributable fraction; YLEL, years of life expectancy lost

Table 1 Study cohorts for the survival analysis of the 10 major smoking related diseases

Diseases	ICD-9CM code	Time period	Maximum period of follow-up (months)‡	No of patients	
				Male	Female
Neoplasms*					
Lip, oral cavity, pharynx	140–149	1996–2001	108	17 253	3370
Oesophagus	150	1996–2001	108	4869	433
Stomach	151	1996–2001	108	12 117	6234
Rectum	154	1996–2001	108	8688	6010
Liver/gallbladder	155, 156	1996–2001	108	31 759	12 143
Lung	162	1996–2001	108	24 039	10 362
Cervix uteri	180	1996–2001	108	–	14 795
Stroke†	430, 431, 434, 436	1995–2000	120	3758	2630
Acute myocardial infarction†	410	1989–1999	192	1202	336
Chronic obstructive pulmonary disease†	491, 492, 496	1991–2000	168	2789	825

*Cohorts were established from the National Cancer Registry database.
†Cohorts were established from National Taiwan University Hospital medical records.
‡31 December 2004 was the designated date for the end of the follow-up period.

1995–2000, AMI cohorts for 1989–99 and COPD cohorts for 1991–2000 were established through medical records provided by the National Taiwan University Hospital (NTUH), a medical centre with about 2000 beds. Because Taiwan is a small island, most, if not all, patients with AMI or stroke can be transferred to a medical centre within two hours. Thus, patients at the NTUH may represent generally more severe cases, but also include mild cases. The dataset on these cohorts was then linked with the National Death Registry database to facilitate our survival analysis.

The end of the follow-up period to ascertain mortality was 31 December 2004 (table 1). The lifetime survival curves of the study diseases were generated based upon the method developed by Hwang and Wang; the expected survival time for the patient cohorts for each disease was then estimated accordingly.[9]

Estimation of medical costs

Estimation of the annual medical costs for patients with each of the study diseases used reimbursement data obtained from the 2001 National Health Insurance (NHI) database. The disease specific mean annual medical costs of the study diseases were subsequently calculated by incorporating the mean annual medical costs and the survival curve. Along with the SAF of these diseases, the total lifetime medical costs were then estimated for all new cases of these smoking related diseases.

Taiwan's NHI is a compulsory national insurance programme which was implemented in 1995, and which now covers more than 97% of the island's population.[10] The NHI database, released for academic use, includes expenditures on inpatient and ambulatory care, and all other claims data. It provides comprehensive information for all cases of cancer; however, with regard to stroke, AMI and COPD, we were only able to obtain a dataset comprising about 200 000 individuals, based upon a stratified random sample from the entire population enrolled in the NHI.

The estimations of the average annual medical costs for each disease were then used to calculate the lifetime medical costs for individual cases of the study diseases. With the exception of AMI, the medical costs for the diseases listed in the NHI reimbursement data were determined by the primary diagnosis of the diseases according to their ICD coding (table 1). We used the code for AMI (ICD 410) to define the medical cost for the first year for AMI, and then used the coronary heart disease code (ICD 411–414) to determine the medical costs for the subsequent lifetime follow-up period. Lifetime medical costs were calculated using the following formula:

$$PVC = \sum_{t=0}^{\infty} S(t) \times C \times \left(\frac{1}{1+r}\right)^{n-1}$$

where PVC is the present value of the lifetime medical costs; S(t) is the estimated survival function for a person acquiring a disease; *n* is time (in years) since the onset of the disease; C represents the mean annual medical costs for each of the study diseases; and r is the annual discount rate, with rates of 1% and 3% being assumed in the estimation. Within the calculation process, we used mean monthly medical costs multiplied by the monthly probability of the survival function. Considering the long term interest rate in Taiwan in 2001 was about 2%, we selected 1% and 3% as the discount rates for this study, even though annual discount rates of 3% or 5%[11] are commonly used for health programmes.

The smoking attributable fraction (SAF) was calculated using the following formula:

$$SAF = \frac{P_0 + P_1(RR_1) + P_2(RR_2) - 1}{P_0 + P_1(RR_1) + P_2(RR_2)}$$

where P_0, P_1 and P_2 refer to the prevalence rates of non-smokers, current smokers and ex-smokers among Taiwanese males and females, respectively; RR_1 is the relative mortality rate for current smokers compared to non-smokers, and RR_2 is the relative mortality rate for ex-smokers compared to non-smokers (based upon a Taiwanese study of the mortality risk for smokers).[7] According to a national health interview survey carried out by the Bureau of Health Promotion in 2001, the smoking prevalence rates among those aged ⩾35 years were 48.0% for males and 4.7% for females. The prevalence of former smokers was 9.5% for males and 0.8% for females. The overall lifetime medical costs attributable to smoking were then estimated by combining the SAF and the total lifetime medical costs for all new cases of the study diseases.

The monetary values were transformed into $US; in 2001, the exchange rate of the New Taiwan dollar ($NT) against the $US was 33.8:1.[12 13]

Annual incident cases attributable to smoking

The total number of incident cases attributable to smoking was calculated by multiplying the number of new cases of each study disease in 2001 by the SAF. The numbers of new cases for cancers (aged ⩾35) was based on the 2001 annual report of the National Cancer Registry.[8] New cases of stroke, AMI or COPD during 2001 were determined as those cases where a patient was being treated for such diseases with confirmed primary

Table 2 Estimated survival time (SD) (in years) and YLEL for patients (age ⩾35 years) developing major smoking related diseases

Diseases	Sex	Mean age at onset	Estimated life expectancy	Estimated YLEL per case
Neoplasms				
Lip, oral cavity, pharynx	Male	53.6 (11.6)	8.1 (0.5)	16.0 (0.5)
	Female	56.5 (13.4)	13.0 (1.5)	12.6 (1.5)
Oesophagus	Male	62.3 (12.3)	2.2 (0.2)	15.3 (0.2)
	Female	70.6 (12.6)	5.2 (1.1)	9.4 (1.1)
Stomach	Male	68.0 (12.0)	5.5 (0.4)	8.1 (0.4)
	Female	64.9 (14.0)	8.9 (0.5)	10.0 (0.5)
Rectum	Male	65.7 (11.6)	9.5 (0.3)	5.6 (0.3)
	Female	65.3 (12.8)	11.8 (0.5)	6.6 (0.5)
Liver/gallbladder	Male	61.3 (12.2)	2.7 (0.1)	15.5 (0.1)
	Female	66.1 (11.1)	3.2 (0.2)	14.4 (0.2)
Lung	Male	68.6 (10.6)	2.0 (0.1)	11.0 (0.1)
	Female	66.5 (12.5)	2.4 (0.2)	15.1 (0.2)
Cervix uteri	Female	56.6 (13.2)	18.6 (0.7)	6.8 (0.7)
Stroke	Male	65.1 (12.0)	9.2 (0.8)	6.4 (0.8)
	Female	67.7 (11.8)	10.1 (1.0)	6.3 (1.0)
Acute myocardial infarction	Male	61.3 (11.7)	13.6 (1.7)	4.5 (1.7)
	Female	68.6 (10.5)	11.4 (1.3)	4.3 (1.3)
Chronic obstructive pulmonary disease	Male	70.0 (10.0)	11.2 (0.5)	0.9 (0.5)
	Female	70.1 (10.5)	11.6 (1.3)	3.0 (1.3)

diagnosis in 2001, but had not been treated for the same disease (according to the primary diagnosis and all secondary diagnoses) during the previous five years (1996 to 2000). By adopting this process, we were able to estimate the total number of incident cases of stroke, AMI and COPD for the aforementioned random sample of 200 000 beneficiaries obtained from the NHI database. The total number of incident cases of stroke, AMI and COPD in 2001 among those aged 35 years was subsequently estimated by adjusting the rate by the nation demographic information on age and sex.

RESULTS

Table 1 presents demographic information on the study cohorts, while details on the estimated survival time and YLEL for patients suffering from the study diseases are presented in table 2.

With the exceptions of oral and cervical cancers, the mean age at the onset of the study diseases was older than 60 years. The mean survival times for lung cancer and cancers of the liver and oesophagus in males ranged between two and three years. The YLEL for oral, liver/gallbladder and lung cancer patients were all greater than 10 years for both sexes; however, the YLEL was less for those patients suffering from COPD.

Table 3 provides the SAF, the estimated incidents and the YLEL attributable to smoking for each of the study diseases. Since only a small proportion of female adults were smokers (<5%), there were far fewer cases among females than among males of the study diseases attributable to smoking. In males, the SAFs were over 40% for oral, lung and oesophagus cancers, and for COPD.

The total number of cases of the 10 study diseases in Taiwan in 2001 was 241 280, of which an estimated 53 648 cases (22.2%) were attributable to smoking. The total YLEL for the study diseases was about 1 032 274 (not shown), with smoking accounting for about 18.5% (191 313 YLEL) and being responsible for an average of about 3.6 YLEL per case.

Of the 10 study diseases, COPD in males accounted for the majority of all incidents attributable to smoking (66.3%), while strokes accounted for the highest YLEL attributable to smoking (16.7%). Cancers of the seven organ systems accounted for only

Table 3 Relative risk (RR), smoking attributable fraction (age ⩾35) and YLEL for major smoking related diseases, 2001

Disease category	Sex	Incidence in 2001	Relative risk*	Smoking attributable fraction	Incidences attributable to smoking	Total YPLLs attributable to smoking (% of grand total)
Neoplasms						
Lip, oral cavity, pharynx	Male	4063	2.60	0.434	1765	28 245 (14.8)
	Female	734	–	–	–	–
Oesophagus	Male	1144	3.18	0.511	585	8952 (4.7)
	Female	88	15.57	0.405	36	335 (0.7)
Stomach	Male	2317	1.68	0.248	574	4652 (2.4)
	Female	1126	–	–	–	–
Rectum	Male	1883	2.06	0.337	635	3557 (1.9)
	Female	1325	–	–	–	–
Liver/gallbladder	Male	6302	1.46	0.181	1140	17 673 (9.2)
	Female	2637	5.03	0.159	418	6025 (3.1)
Lung	Male	4587	2.73	0.454	2081	22 896 (12.0)
	Female	2121	3.36	0.099	211	3185 (1.7)
Cervix uteri	Female	2317	5.78	0.183	424	2880 (1.5)
Stroke	Male	28 488	1.71	0.254	7243	46 357 (24.2)
	Female	20 589	1.71	0.032	662	4171 (2.2)
Acute myocardial infarction	Male	7769	1.80	0.278	2156	9703 (5.1)
	Female	3895	1.90	0.040	157	677 (0.4)
Chronic obstructive pulmonary disease	Male	74 739	2.89	0.476	35 559	32 003 (16.7)
	Female	75 156	–	–	–	–
Grand total		241 280			53 648	191 313 (100)
Grand total (without COPD)		91 385			18 089	159 310

*Wen *et al*.[7]

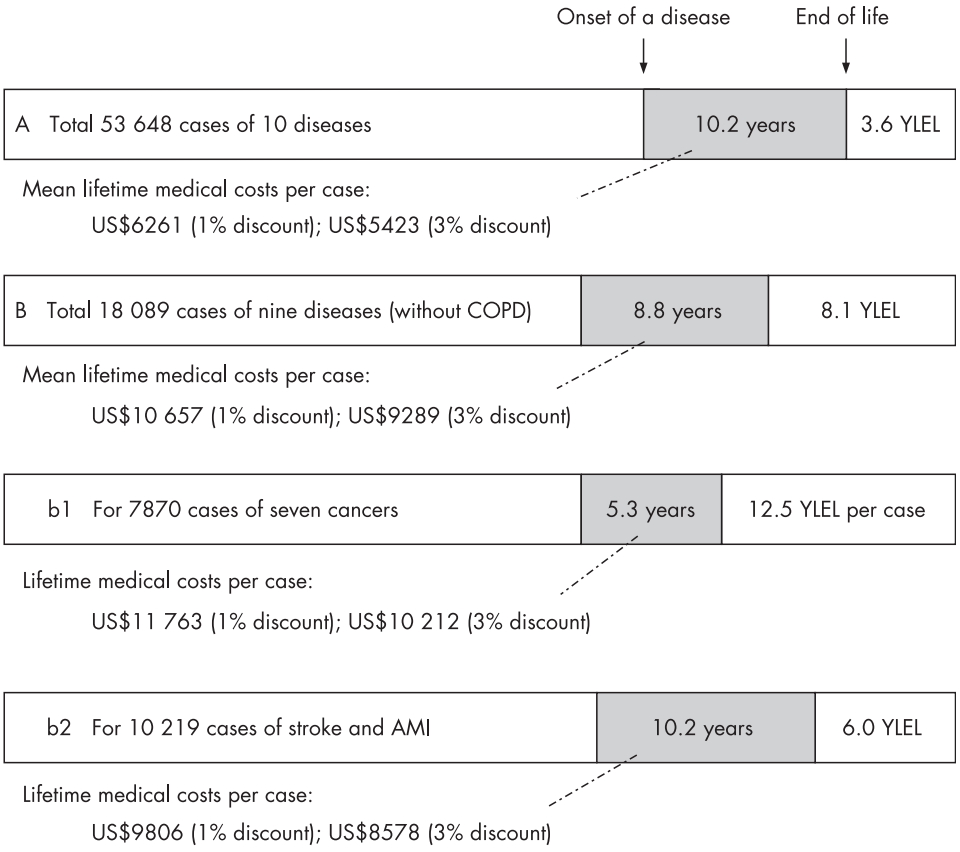

Figure 1 Incidence based estimates of YLEL and lifetime medical costs attributable to smoking for cases (age ⩾35) of major cigarette smoking related diseases in Taiwan, 2001. YLEL, years of life expectancy lost; COPD, chronic obstructive pulmonary disease; AMI, acute myocardial infarction.

14.7% of all incidents attributable to smoking, but up to 52.0% of the total YLEL attributable to smoking. In all, males accounted for 91.0% of total smoking related YLEL for the 10 study diseases.

The estimated lifetime medical costs attributable to smoking for the 10 study diseases are presented in table 4 and figure 1. For individual cases of the study diseases, the estimated lifetime medical costs were greater for oral cancer in males and cervical cancer in females than for all other diseases. The total lifetime medical costs for incidents attributable to smoking in 2001, however, were greater for COPD and strokes among males.

Based upon the two different annual discount rates, the total lifetime financial burden on the National Health Insurance was estimated at $336 million (at the 1% discount rate) and $291 million (at the 3% discount rate). For both discount rates, the figures represented about 24.6% of the total lifetime medical expenditures ($1.37 and $1.18 billion) for all incident cases of the 10 study diseases, with about 95% of these amounts being attributable to males. The lifetime medical costs for stroke, AMI and COPD attributable to smoking accounted for up to 72% of the total costs, while those for cancers of the seven organ systems accounted for the remaining 28%.

DISCUSSION

The main purpose of this study is to draw attention to not only the financial burden due to tobacco mortality, but also to the premature deaths and chronic suffering from smoking related diseases. In this study, we have adopted an incidence based approach to explore the loss of life expectancy, survival time after contracting a smoking related disease, and the lifetime medical cost attributable to smoking. In addition to the financial burdens to the National Health Insurance and victims' families, each patient will also suffer physically, emotionally and socially before dying. It is important to present evidence not only on the financial burden of tobacco on society, but also on the chronic morbidity suffered by victims and the loss of life expectancy.[14]

Although it has been argued in some studies that the reduced life expectancy for smokers may actually offset the increased utilisation of medical services,[15] this argument ignores the fact that loss of life expectancy and chronic morbidity, in itself, has tremendous impacts for both smokers and their families. Brønnum-Hansen and Juel demonstrated that smoking during a person's lifetime reduced their expected period of good health and increased their expected period of poor health.[16] Future estimations of survival could also incorporate information on quality of life (QOL) to obtain estimations of the loss of quality adjusted life years (QALY) caused by smoking.[17] This will ultimately broaden the horizon for the assessment of the health impacts attributable to smoking.

In all, COPD, strokes, oral cancer and lung cancer in males accounted for about 68% of the total loss of life expectancy, while COPD, stroke, AMI and oral cancers accounted for about 81% of the total lifetime medical costs. COPD alone accounted for 16.7% of the total YLEL and 42.4% of the total lifetime medical costs, essentially as a result of its high incidence rate relative to other diseases. Moreover, there were at least more than two years of suffering (survival periods) if a smoker contracted any of these related diseases before premature death.

Of all instance of diseases attributable to smoking in 2001, 96.4% involved male smokers, who also accounted for 91.0% of the total YLEL attributable to smoking. As for the estimated total of all smoking related lifetime medical costs in 2001, about 94.5% was attributable to males.

Limitations

The calculations undertaken in this study may still underestimate the true costs attributable to smoking, for the following reasons. (i) We have not included the effects of secondhand smoke. (ii) We have not explored the negative

Table 4 Estimated lifetime medical costs for major smoking related diseases

Disease category	Sex	Mean annual medical costs ($)	Estimated lifetime medical costs per case ($)		Incidences attributable to smoking	Total lifetime medical costs, attributable to smoking, $1000		% of grand total
			1% Discount	3% Discount		1% Discount	3% Discount	
Neoplasms								
Lip, oral cavity, pharynx	Male	2706	20 093	17 353	1765	35 471	30 634	10.5
	Female	1438	16 646	13 612	–	–	–	–
Oesophagus	Male	4956	10 560	9656	585	6179	5650	1.9
	Female	438	2031	1660	36	72	59	0.0
Stomach	Male	2559	12 994	11 188	574	7462	6425	2.2
	Female	2129	16 583	13 255	–	–	–	–
Rectum	Male	1962	16 792	14 135	635	10 666	8978	3.1
	Female	1659	17 478	14 287	–	–	–	–
Liver/gallbladder	Male	2339	5990	5430	1140	6830	6191	2.1
	Female	1843	5525	4963	418	2312	2077	0.7
Lung	Male	3513	6619	6001	2081	13 777	12 491	4.2
	Female	3038	6882	6209	211	1452	1310	0.4
Cervix uteri	Female	1222	19 730	15 468	424	8357	6552	2.4
Stroke	Male	1158	9858	8641	7243	71 404	62 589	21.4
	Female	938	8744	7535	662	5790	4989	1.7
Acute myocardial infarction	Male	2083	10 318	9002	2156	22 248	19 410	6.6
	Female	1643	4868	4270	157	766	672	0.2
Chronic obstructive pulmonary disease	Male	390	4025	3457	35 559	143 125	122 927	42.4
	Female	191	2046	1773	–	–	–	
Grand total					53 648	335 910	290 954	100.0
Grand total (without COPD)		–	–	–	18 089	192 785	168 027	

impacts of smoking during pregnancy, which may well give rise to long term impairments among the offspring of smokers.[18] (iii) Only relative risks at statistically significant levels from Wen's cohort were included within the calculation of SAF. As the women in Wen's study were much younger than in the general population, and given the low prevalence of smoking among women (that is, about 1.4%), it was not surprising that there was a small number or zero cases of observed deaths; thus, we report no health effects attributable to smoking for four of the cancer diseases and COPD among females. (iv) Given the lack of appropriate cohorts, our study has focused on only 10 diseases, which would certainly lead to underestimation of the impacts on health in general as a direct result of smoking. (v) Our study also used the mortality based relative risk as the means of calculating the SAF, and did not explore the impact of smoking on either general health or on the quality of life during the lifespan of an individual. (vi) Our estimations were limited to direct medical costs (covered by NHI), so we did not consider human capital loss or indirect costs, such as lost productivity due to morbidity, disability or premature death caused by smoking related illnesses. (vii) The age, sex matched general population of this study is based on the vital statistics of Taiwan that included both smokers and non-smokers, and thus would underestimate the life expectancy and YLEL.

Although this study intends to estimate smoking related health impact on incident cases, only the smoking attributable fraction based on mortality data was available. Thus, we might overestimate the number of deaths caused by COPD, as patients might also have co-morbidities, including cancer and more fatal diseases. However, people with COPD may not be certified as dying of this disease because the mortality data in Taiwan have been generally coded with only one underlying cause of death that is less likely to be COPD if a person also had a major cancer. Thus, the estimation of smoking attributable fraction of COPD might be affected and the total incidence might be underestimated, which offsets the potential of previous overestimation. Future studies based on collection of incidence data to derive relative risks, healthcare expenditures, quality of life measurements, as well as a more valid contrast of smokers versus non-smokers are needed to make a more accurate estimation of the total cost of tobacco smoking.

What is already known on this subject

- In general, smoking contributes to approximately 6–14% of personal healthcare expenditure among adults, accounting for about 6.8% of the total medical expenditure on people aged 35 and above in Taiwan in 2001.

What this study adds

- Through an incidence based approach and survival analyses, this study provides information on the lifetime costs of 10 major smoking related diseases, including medical expenditure, life expectancy after contracting a particular disease and years of life expectancy lost.
- This study applies a novel approach to depict the potential health and economic burdens attributable to smoking.When reporting on the costs resulting from tobacco use, it is important for public health activists not to neglect the costs of the suffering endured throughout the period of illness and the consequent loss of life expectancy.

CONCLUSIONS

Smoking places a tremendous health and financial burden on society as a whole; indeed, we have estimated that about 24.7% of the financial burden on the NHI and a total of 191 964 YLEL were attributable to smoking for the ten smoking related diseases in Taiwan in 2001. For individuals, these are preventable risks, which can ultimately be eliminated entirely by the cessation of smoking or by not smoking in the first place. More stringent tobacco control policy is needed if we are to succeed in lowering the smoking rate, particularly among males, and in halting the rise in the prevalence rate of smoking among females. The result would provide policy decision

makers with sufficient guidance for the implementation of appropriate tobacco control and disease prevention policies.

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The Lighter Side

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University of California Regents engage in lengthy and acrimonious debate over a motion to ban the university from accepting tobacco industry research funding.