Smokers' Burden on Society: Myth and Reality in Canada

ANDRÉ RAYNAULD
University of Montreal
and JEAN-PIERRE VIDAL

Plusieurs auteurs soutiennent que les fumeurs sont à la source de coûts considérables pour la société: frais d'hospitalisation et de services médicaux et production perdue par le décès prématuré des fumeurs. Pour l'année 1986, au Canada, nous estimons à $669 millions les coûts supplémentaires reliés à l'usage du tabac. Par contre, comme la réduction des coûts futurs de santé s'élève à $462 millions, les coûts externes nets n'atteignent que $207 millions. Ces coûts donnent lieu à un transfert, mais ils sont surcompensés par d'autres transferts tels que les taxes payées par les fumeurs et les réductions des prestations des régimes de retraite. En réalité, il se produit ainsi un transfert net global des fumeurs en faveur des non-fumeurs de l'ordre de $4.3 milliards. Même en considérant un éventail très large d'hypothèses médicales, le sens de cette conclusion ne change pas.

Several authors maintain that smokers impose a considerable burden on society through hospitalization and medical costs and lost output due to premature death. In this paper, supplementary costs related to smoking are estimated at 669 million dollars for the year 1986 in Canada. However, since future health cost reductions reach 462 million, the net external costs generated do not exceed 207 million. These costs give rise to transfers, but these in turn are more than compensated by other transfers such as taxes paid by smokers and reductions in pension benefits which lead to a net flow overall of 4.3 billion dollars in favour of non-smokers. The direction of this conclusion remains unchanged even considering a wide range of medical hypotheses.

I Introduction

There is a strong current of opinion to the effect that tobacco being harmful to the health, smokers impose extra expenditures on society and become a financial burden for non-smokers. To quote only one representative example,[1] L. Bartlett (1988), writes:

> The net result [of smoking in Canada] is that it costs each Canadian $100 annually in health care related costs so that 35% of their countrymen can smoke.

It is the purpose of this article to determine if observations such as this one are valid or not. The analysis is based on two fundamental concepts or criteria: externalities and inter-group transfers. A smoker may be responsible for hospitalization costs which become an external cost in Canada given the public nature of the health care system. In this instance, the smoker imposes a cost on others. The question then arises: who pays for what and who benefits between smokers and non-smokers. This calls for an examination of transfers between the two groups. In the previous example, non-smokers finance a

Canadian Public Policy – Analyse de Politiques, XVIII:3:300–317 1992 Printed in Canada/Imprimé au Canada

Table 1
Relative risks coefficients (ψ)

Disease	Lowest value		Highest value*	
	Men	Women	Men	Women
Malignant neoplasm of				
oral cavity	2.76	1.22	13.00	3.25
esophagus	1.82	4.89	6.43	4.89
stomach	1.39	1.31	1.80	2.30
pancreas	1.50	1.42	3.10	2.50
larynx	6.52	3.25	13.59	6.52
trachea, bronchus and lung	3.76	2.03	14.20	5.00
cervix uteri		1.72		3.00
bladder	1.40	1.66	2.89	2.80
kidney	1.20	n/a	2.66	2.66†
Ischaemic heart diseases	1.58	1.30	1.71	1.78
Bronchitis and emphysema	12.07	n/a	24.70	24.70†

This table reads as follows: taking for example the highest value for men, the risk of death from oral cavity cancer is 13 times higher for smokers than for non-smokers.
SOURCE: US Department of Health and Human Services (USDHHS, 1982, 1983, 1984).
* The highest values are used as our basic assumptions, as stated above.
† A relative risk coefficient was not established for kidney cancer and pulmonary diseases in women; therefore, we adopted the coefficients given for men.

good proportion of supplementary health costs, so that transfers go from non-smokers to smokers. On the other hand, smokers pay taxes on tobacco which benefit non-smokers to a large extent. In this case, the transfers go in the opposite direction. A complete balance sheet of revenues and expenditures accruing to smokers and non-smokers is necessary before one can conclude whether or not smokers are a burden on non-smokers.

II Basic Assumptions

This study is based on three major assumptions: 1/ smoking is harmful to the health of smokers; 2/ smoking is not harmful to the health of non-smokers; and, 3/ smokers know that smoking is detrimental to their health.

Smoking is Harmful to Smokers
Numerous medical studies show that consumption of tobacco is harmful to the health of smokers. Since our expertise does not lie in the medical field, we simply use the findings published by the Surgeon General of the United States[2] as working hypotheses without endorsement.[3] They take the form of relative risk coefficients (ψ) associated with a broad range of diseases.[4] These coefficients give the relative risk of dying if one is a smoker as opposed to a non-smoker. Since several estimates are often given for the same illnesses, we have always chosen the highest values for our calculations so as to avoid any suggestion that we have selected hypotheses favourable to our conclusions. It will be obvious that with higher risk coefficients, related health cost estimates will also be higher than otherwise. Table 1 gives the highest and lowest estimates of risk coefficients as has been found in the Reports of the Surgeon General.

The risk coefficients will be used to estimate the proportion of costs imputable to tobacco; those costs are broken down according to the International Classification of Diseases (ICD-9). As a result, a correspondance had to be established between the diseases given in Table 1 and those of ICD-9.

For cancer of the oral cavity, we used the

broader category *Malignant neoplasms of the lip, oral cavity and pharynx*. This is consistent with our practice of always opting for the least favourable choice. For cancers of the oesophagus, stomach, pancreas, larynx, trachea, bronchus and lung, cervix uteri, and bladder, ICD-9 provided a corresponding listing of diseases under the same names. For bladder cancer, we chose *Malignant Genito-urinary Organ Tumors, Kidney and Other Urinary Organs n.o.s.*, a subcategory that includes kidney cancer but extends beyond it. For ischaemic heart disease, a corresponding category of the same name was chosen from ICD-9. Finally, for bronchitis and emphysema, we selected the very broad category *Respiratory System Diseases, Chronic Obstructive Pulmonary Disease and Allied Conditions*; as usual, we made the choice to bear most unfavourably upon our findings.

To the 11 diseases of Table 1 we associated 30 diseases, when considering the three digit disaggregation of the ICD-9 classification.

The Health of Non-smokers

There is a widespread opinion to the effect that smoking is harmful to the health of non-smokers. It is based mainly on strong statements made by the Surgeon General of the United States, such as the following one taken from his 1986 report (p.13):

> Involuntary smoking is a cause of disease, including lung cancer, in healthy non-smokers.

We found however that the evidence in support of this opinion is far from conclusive.

Concerning lung cancer among spouses, the 1986 review of the US Surgeon General is largely an examination of three prospective and ten retrospective studies.[5] Highlights of these findings, provided in his tables 7, 8 and 9, can be found in our Table 2.

In our judgment, Table 2 does not support the Surgeon General's thesis, since two thirds of the studies tabled – nine out of 13 – do not provide relative risk coefficients statistically different from one. Of the four studies which would support the Surgeon General's thesis that smoking is dangerous for non-smokers, the findings of two are highly tenuous. With reference to the study by Trichopoulos, the Surgeon General (USDHHS, 1986) observes that some biases may have arisen in the selection and interview process. As well 'the diagnosis of cancer was not confirmed for 35 per cent of the cases'. In the study by Correa et al. the sample was limited to 30 cases overall. Finally, this comment found in the Surgeon General's Report (USDHHS, 1986) and concerning the study of Garfinkel would make anyone suspicious of the results obtained in this area of research:

> Among the published studies on involuntary smoking, this is the only one involving independent verification of the diagnoses of all cases. This verification showed that 13 percent of the cases classified as lung cancer were not primary cancers of the lung. This study showed that 40 percent of the women with lung cancer who had been classified as non-smokers (or smoking not stated) on hospital records had actually smoked, compared with 9 percent of the controls. The inclusion of lung cancer patients who had actually smoked, *would have substantially increased the odds ratio with involuntary smoking,* because 81 percent of the potentially mis-classified cases had husbands who smoked, compared with 68 percent of the 'true' non-smoking patients with lung cancer.[6]

Other remarks by the Surgeon General deserve attention. For example, on page 91 of the same report, we find this observation concerning tobacco use by parents:

> None of the studies with data on parental smoking had sufficient numbers to examine the effects of parental smoking on non-smokers.

Similarly, we find this observation about the use of tobacco in the workplace:

> The workplace, an important source of tobacco smoke exposure, was not considered in the early studies on involuntary smoking. Later case-con-

Table 2
Summary results on passive smoking relative risk coefficients for lung cancer

Study	Sample	Cancers	Significant results at 5%
		Prospective studies	
Hirayama 1981, 1983, 1984	91,450	200	$\psi = 1.9$ for women whose husbands smoked more than 20 cigarettes daily
Garfinkel 1981	176,739	153	None
Gillis et al. 1984	2,744	14	None
		Retrospective studies	
Study		Cancers	Significant results at 5%
Trichopoulos 1981, 1983, 1984		77	$\psi' = 2.5$ for women whose husbands smoked more than 20 cigarettes daily
Correa et al. 1983		30	$\psi' = 3.1$ for those whose partners smoked more than 40 packs yearly
Chan and Fung 1982		84	None
Koo et al. 1983, 1984		88	None
Kabat and Wynder 1984		78	None
Wu et al. 1985		29	None
Garfinkel et al. 1985		134	$\psi' = 2.1$ for women whose husbands smoked more than 20 cigarettes daily
Lee et al. 1986		47	None
Akiba et al. 1986		103	None
Pershagen (in print)		67	None

SOURCE: US Department of Health and Human Services (USDHHS, 1986).

trol studies provided some information on tobacco exposure at work, but the data were limited and inconclusive.

Concerning the relationship of 'passive' smoking to other cancers, the Surgeon General writes:

There are, at present, insufficient data to adequately evaluate the role of involuntary smoking in adult cancers other than primary carcinoma of the lung.

With regard to cardiovascular disease, the Surgeon General writes:

More detailed characterizations of exposure to ETS [Environmental Tobacco Smoke] and specific types of cardiovascular disease associated with this exposure are needed before an effect of involuntary smoking on the etiology of cardiovascular disease can be established.

For all these reasons, we assume in this study that smoking is not a cause of death among non-smokers.[7]

Smokers Know that Smoking is Detrimental to Their Health

Finally, we assume that smokers are aware that smoking may be harmful to their health. Such an assumption is especially reasonable in Canada, where the tobacco industry is required to display very prominent warnings on all cigarette packages.

Indeed, such warnings must occupy an area equal to 20 per cent of the principal panels of the cigarette pack. They must be 'legible and prominently displayed in contrasting colours,' and the message is unambiguous:

Smoking reduces life expectancy.
Smoking is the major cause of lung cancer.
Smoking is a major cause of heart disease.
Smoking during pregnancy can harm the baby.

If the numerous anti-smoking campaigns are added to these warnings, it would be simply unrealistic to assume that smokers are not aware that smoking may be hazardous to their health.

Yet, one could argue that people still underestimate the risks or do not pay enough attention to these warnings. But this view would not be consistent with the findings of W.K. Viscusi (1990):

> This paper uses a national survey of 3,119 individuals to examine the effect of lung cancer risk perceptions on smoking activity. Both smokers and nonsmokers greatly overestimate the lung cancer risk of cigarette smoking, and the extent of the overestimation is much greater than the extent of underestimation.

One could still argue that in the 1940s and 1950s when smoking was portrayed as glamorous and good, people began smoking but that now they find it very difficult to quit.

This is correct as a statement of fact but irrelevant in the context of this analysis. The real point is whether there is or there was a market failure giving rise to external costs as opposed to private costs such as loss of income due to premature death attributed to tobacco.

Even in the 1940s nobody hid the truth from smokers because nobody knew that tobacco was so harmful to the health. Indeed, the problem at hand is not a problem of information but rather of uncertainty. Moreover, it is not because many see smoking as addictive that an external cost results automatically. Indeed, using a rational addiction model, G.S. Becker and K.S. Murphy (1988) show that a consumer may be perfectly aware that smoking is harmful and addictive, and, in spite of that, decide to smoke to maximize his/her utility over time.[8]

In other words, if decisions are taken in full knowledge of the consequences as they exist at the time the decision is made, this becomes a purely private and rational decision involving no more than private utility and costs.

III External Costs

To determine whether smokers are a burden on society, one must first establish the importance of external costs related to smoking. In application of our first assumption above, supplementary medical and hospital costs are involved and they are deemed to be external given the public nature of the health care system in Canada. We also include costs associated with fire losses imputed to negligent smokers.

Various other costs are mentioned in the literature but not included herein, such as: 1/ time lost on the job due to smoking; 2/ absenteeism without loss of pay; 3/ additional cleaning and ventilation costs in areas used by smokers; 4/ the price non-smokers would pay to be always smoke-free; and 5/ the price relatives and friends would pay to reduce the risk of a smoker's death.

The first two categories of costs are held to be negligible when they are compared with all the other reasons or pretexts to waste time on the job or stay away from work. Moreover, in a majority of cases, the alleged external cost is very much a private cost; people are not paid when they do not work or they lose either money or leisure from taking 'sick days,' which are interchangeable with additional wages or days off.

In any case, if smoking had been significantly related to costs for the employer, or to productivity, then smokers' wage rates would certainly have reflected it. If they did not, one cannot easily dismiss the idea that smoking was an excuse that might easily be substituted for another one, like having a coffee or a soft drink. Furthermore, in a study involving 33,032 individuals, C.E. Bonilla (1989) found that smoking had no bearing on absenteeism.

The same applies to cleaning and ventilation costs. If a systematic association had been established involving smokers, market forces would have led to lower salaries and smokers would have internalized the

Table 3
Proportion of cigarette smokers among Canadians (percentages) 1986

Sex	Age 15–19	20–24	25–44	45–64	65+
Men	17.40	31.30	35.40	33.60	18.60
Women	17.80	32.00	31.40	25.30	11.30

Note: The proportion of smokers in the overall population is 22.12%. It is found by applying the proportions of Table 3 to the total population by age group and sex, found in Statistics Canada (1988), summing them up and taking the percentage. The 0 to 15 age group is assumed not to contain regular smokers.
SOURCE: Health and Welfare Canada (1988).

costs. Time lost in the work place as well as cleaning and ventilation costs are not real external costs.

On the other hand, the price non-smokers would pay to live in a smoke free environment is a genuine externality. However, smokers would undoubtedly be willing to pay to smoke wherever they like and not be blamed for it. This externality, in the opposite direction, could very well cancel out or even more than offset the external cost borne by non-smokers. This is especially true now, since new laws and internal regulations forbid smoking in many public and work places.

Finally, even if those close to smokers were prepared to pay to reduce the risk of death, this cost cannot be considered purely external, since friends and relatives share their concerns with the smoker, who is very likely to take their views into account.

For those reasons, we have not included these considerations in our evaluation.

On the other hand, if we follow the logic of the situation and demonstrate that smokers risk premature death, we must accept the fact that smokers stop requiring the health services they would have required had they not smoked and lived longer. As we will see in section V (Methodological Issues), several authors support this logic.

Therefore, to arrive at a net value of externalities, one has to calculate the reduction of health costs due to premature death and balance it against the supplementary costs attributable to smoking.

Additional Hospital Care Costs

The computation of supplementary hospitalization costs is based on the proportions of cases attributable to smoking, for each disease, each sex, and each age-group, proportions that are called etiologic fractions (λ) and are defined as:

$$\lambda = \frac{\theta(\psi\text{-}1)}{\theta(\psi\text{-}1)+1},$$

where θ is the proportion of the population by age and sex exposed to the risk factor and ψ is the relative risk coefficient.[9] θ is given above in Table 3, and ψ has already been given in Table 1.

The computation of costs was then carried out as follows:

(1) The number of hospital care days, throughout Canada in 1986, was established for each relevant disease or category of disease, each sex, and each age-group.[10]

(2) These numbers of days were then multiplied by the corresponding etiologic fractions, by age, and by sex, to obtain the number of hospital care days attributable to smoking, that is, the number of hospital care days that presumably would have been saved had no one smoked.

(3) The sum over diseases, sex, and age-groups multiplied by $352.22, which is taken to be the average cost of one hospitalization day, gave $546.5 million.[11]

Although the calculations are very simple, they are so numerous that it is impossible to give a detailed account of the more than 7,000 pages of tables that could

Table 4
Additional hospital care costs: summary of intermediary results for men 1986

International classification of diseases – 9th revision (ICD – 9)	Total number of hospital days	Proportion attributable to smoking (%)	Hospital days attributable to smoking	Imputed hospital cost (million dollars)
Malignant neoplasms				
lip, oral cav. and phar. (140–149)	55,739	75	41,805	14.7
esophagus (150)	29,228	57	16,636	5.9
stomach (151)	64,285	16	10,011	3.5
pancreas (157)	48,041	33	15,788	5.6
larynx (161)	33,859	76	25,626	9.0
trachea, bronchus and lung (162)	343,995	75	258,605	91.1
bladder (188)	92,897	29	26,994	9.5
kidney and other urinary organs n.o.s. (189)	41,147	29	11,784	4.2
Ischaemic heart diseases (410–414)	1,077,802	15	162,672	57.3
Chronic obstructive pulm. dis. and allied cond. (490–496)	651,273	72	468,015	164.8
Overall	2,438,266		1,037,937	365.6

Notes:
Due to rounding, totals may differ slightly.
The proportion of days attributed to smoking is a weighted average of the etiologic fractions defined above as the proportion of cases attributable to smoking by age, sex, and disease. The etiologic fractions themselves are somewhat higher than the average values. For instance, 89% of all days spent for men aged 25 to 44 and suffering from a chronic obstructive pulmonary disease were attributed to smoking. This might be surprising when compared with the average value of 72%, but it results from the fact that no cases were attributed to smoking under the age of 15.
Cancer of the cervix uteri has been deleted from this table but it has been taken into consideration for women.

be accounted for in this whole study. However, Table 4 has been constructed as a heuristic device to show the kind of operations involved. Taking the first line as an example, the total number of hospitalization days spent for malignant neoplasms of the lip, oral cavity, and pharynx was 55,739 in 1986 for men. Since the proportion attributable to smoking was established at 75 per cent, the number of hospitalization days attributed to smoking was 41,805. At $352.22 per day, the corresponding cost amounts to $14.7 million.

Additional Medical Services Costs

In this case, we had to extrapolate from statistics relating to Saskatchewan to arrive at an overall picture for Canada, because this is the only provincial authority gathering the required data on the specific illnesses.

With reference to Saskatchewan, during 1986–87, $4.7 million was spent for neoplasms; $4.7 million for diseases of the circulatory system; and an additional $5 million for chronic obstructive pulmonary diseases.[12]

Since Saskatchewan's overall health services cost $184.8 million in 1985, while the cost for all Canada was $6.3 billion, we arrived at a multiplication factor of 33.82, which when applied to the previous numbers gave Canadian extrapolations of $159.1 million for neoplasms; $160.2 million for diseases of the circulatory system; and $167.6 million for chronic obstructive pul-

monary diseases.

Finally, assuming that the cost of medical services attributable to smoking was proportional to the number of hospital days due to the same cause, we obtained a cost for medical services attributable to tobacco of approximately $68 million: $22 million for neoplasms; $5 million for diseases of the circulatory system; and $41 million for diseases of the respiratory system.

The Cost of Smokers' Negligence

In table 5 of the Federal Fire Commissioner's annual report (Labour Canada, 1987), property losses from fires blamed on smoking are listed at $52.2 million for 1986.

To these property losses we added $2 million for the nation's reduction in well-being resulting from the loss of wooded land. Our reasoning was as follows:

1/ We knew the fight against forest fires costs $102.3 million in 1986, and that fires blamed on 'recreation' account for 2 per cent of devastated areas (see Petawawa National Forestry Institute, 1989).

2/ So, assuming that the government would keep spending money to protect the environment until the value of the lost environment would be worth no more than the money spent to protect it, we estimated that the value of the wooded land lost represented at most 2 per cent of $102.3 million. Obviously, this is an overestimation because the category 'recreation' is much broader than the 'negligence on behalf of a smoker'.[13]

The Reduction of Future Hospital Care Costs

Consistent with the extreme assumptions adopted for the hazards of smoking, we imputed 21,841 deaths to tobacco use by applying the etiologic fractions to the statistically recorded deaths in Canada by cause, age, and sex. Subsequently, a model representing the anticipated life and death of each of these deceased individuals has been constructed, assuming that all of them died earlier than they would have had they not smoked.[14]

The fundamental premise leading us to infer a reduction in future cost is that although smokers might have lived longer had they never smoked, they would nevertheless have been subject to the same risks as any non-smoker. At one time or another, they would have been ill, and, eventually, most would have spent some time in the hospital.

Consequently, in our 'life-and-death' model, each prematurely deceased individual is classified according to the year of his or her unavoidable demise (the moment when he or she would have died anyway), the cause of that demise, and the age that he or she would have reached at that time. From this information, we computed the following reduction in hospital care costs:

1/ For each year, from 1986 to 2071, the number of deaths by ICD-9 category and by age was multiplied by the average length of a hospital stay (in days) relevant to each category and age. Summing up over categories and ages, a number of hospitalization days saved was then obtained for each year from 1986 to 2071. (There would be no survivors alive after 2071. Since no one died from smoking before being 15 years old, nobody would live beyond the age of 100 years: 2071-1986 + 15).

2/ Again, for each year from 1986 to 2071, the previously obtained numbers of hospitalization days were multiplied by the average cost of each day, established at $352.22 for 1986–87, and assumed to remain at that level in constant dollars.

3/ Finally, the present value was taken at an annual compounded real discount rate of 3 per cent.[15]

From the above calculations, we estimated the reduction in hospital care cost at $133.4 million.

It is worth indicating that this amount is probably a significant underestimation, since our calculations *do not reflect hospital stays not directly related to the ultimate death of the individuals concerned.*[16]

The Reduction of Future Medical Services Costs

From our 'life-and-death' model, we also obtained the number of deceased smokers who might have survived in each of the years from 1986 to 2071. It was then possible to estimate the value of medical services saved because of these premature deaths. Our methodology can be described as follows:

1/ Had the dead smokers never smoked and lived longer, we assumed that, at any specific age, they would have required, on average, the same kind of medical attention as anyone else at that age; consequently, their average medical costs would have been the same as those of other citizens.[17]

2/ We then applied the average cost of medical services, broken down into five-year age spans, to the number of deceased smokers who, presumably, would have survived. As above, the present value was taken at a 3 per cent discount rate.

The reduction in future medical services was established at $123.5 million.

The Reduction in Residential Care Facilities for the Aged

Finally, we considered the reduced expenditure on residential care facilities for the aged.

1/ We assumed that the number of old age beneficiaries of residential care, expressed as a percentage of the total population by age group, would remain constant after 1986,[18] as well as the average cost borne by society at $35.17 per day (in 1986 dollars).[19]

2/ Subsequently, we applied the proportion of old age beneficiaries to the number of deceased smokers for each year from 1986 to 2071, taking into account age and sex, to calculate how many of them would have been beneficiaries had they not succumbed in 1986.

3/ Finally, by straightforward multiplication of the above figures by $35.17, we arrived at the annual amounts saved from 1986 to 2071.

Taking the present value, we arrived at a reduced cost for residential care facilities for the aged of $204.9 million.

The Net Cost of Externalities

Based on our extreme assumptions about the risks run by smokers, we estimate the net external cost of smoking in Canada for 1986 at $207 million.

This figure includes supplementary costs presumably incurred because some people smoke: $546.5 million in hospitalization; $68.1 million in medical services; $52.2 million in property losses from fire; and $2 million for the destruction of part of the nation's wooded land, for a total of $668.8 million.

Reductions in future costs include: $133.4 million in hospitalization; $123.5 million in medical services; and $204.9 million in residential care facilities for the aged. Substracting this $461.8 million reduction from the $668.8 million, we arrive at a net external cost of $207 million.

IV Transfers

The next question is how much of this net external cost of $207 million is paid by the smokers themselves and how much is paid by non-smokers. Put in these terms, it becomes obvious that the question is only a small part of a much broader issue.

To determine whether smokers overall constitute a financial burden on non-smokers or on society as a whole, it is not enough to determine if taxes paid by smokers are sufficient to cover the expenses they are responsible for. In addition we have to estimate the relevant taxes smokers would have paid had they lived longer and also, we have to include the net savings related to pension benefits, which are reduced by the early deaths of smokers.

The Transfers from Externalities

In the preceding section we established the net external cost of smoking at approximately $207 million. Since we estimate that 69.15 per cent of taxpayers are non-

smokers[20] $143 million will be financed by non-smokers. This amounts to a transfer of $143 million from non-smokers to smokers.

However, there are people of working age among the deceased smokers who would have lived longer, had they not smoked. Then, we must estimate the taxes they would have paid. The following describes our methodology:

1/ According to Health and Welfare Canada (Table 6), in 1986, the costs of hospitalization and medical services were $17.5 billion and about $7 billion respectively.

2/ According to Statistics Canada (1989b:119), the cost of residential care facilities for the aged was approximately $3 billion, which means that applying our 65 per cent rule, $2 billion was paid for from public sources.

3/ According to our calculations, there were 12 million Canadian workers in 1986.

4/ Thus, assuming that the costs were fully recovered by the government from the taxpayers, each taxpayer contributed $2,252.70.

5/ Assuming that this contribution would remain at that level in constant dollars, we multiplied it by the number of deceased taxpayers for each year after 1986.

Taking the present value as we did before, we estimated the contribution of deceased smokers, had they not smoked, at $146 million. Of this amount, $100.9 million (69.15%) represents a reduction of the financial advantage to non-smokers. The net transfer relative to external cost, from non-smokers to smokers, is therefore approximately $244 million (143 + 100.9).

The Transfers through Tobacco Taxes

Smokers paid $4.1 billion in tobacco taxes, over and above the taxes paid by non-smokers in 1986. However, the transfer going from smokers to non-smokers is not equal to that amount because smokers benefit as well as non-smokers from the public services they finance. More precisely, since non-smokers represent 77.88 per cent of the population, they benefit from smokers' taxes by approximately $3.2 billion.

To obtain this total of $4.1 billion, we simply added the federal and provincial consumption taxes on tobacco. Federal taxes have been established at $1,948.3 million: $277.3 million for the federal sales tax;[21] $1,107.5 million for the excise tax; $552.6 million for the excise duty;[22] and $11 million for the tariff duty.[23] Provincial sales taxes have been established at $2,119.7 million. This estimate applies to calendar year 1986, and comes from Statistics Canada (1986).[24]

The Transfers through Pension Plans

We assumed at the outset that smoking was hazardous to health and that, as a consequence, smokers had a shorter life expectancy than non-smokers. Consistent with that assumption, we find that if smokers die earlier than non-smokers with similar pension benefits, there must be a transfer in favour of non-smokers and to the detriment of smokers. We estimate this transfer at $1.4 billion.

In 1986, total contributions to pension plans amounted to $29.5 billion.[25] Since there were 11.8 million workers, the average contribution was about $2,504.13.

On average, for the same year, the Old Age Security and Supplement regimes paid out $4,604.71 to 107 per cent of the 65 and over age group (because spouses' allowances are also paid to those less than 65 years old, as are pensions to Canadians abroad); Canada and Quebec Pension Plans $2,865.73 to 96 per cent of those 65 and over; and private pension plans $7,261.27 to 45 per cent of those 65 and over.

From these observations, we undertook the following calculations:

1/ From the calculations we referred to previously, we know how many deceased smokers would have worked, had they not smoked, for each year after 1986. To determine how much they would have contributed to financing pension funds, we multiplied that number by the average contribution of $2,504.13.

Table 5
Total net transfers from smokers to non-smokers 1986

	In millions of dollars
Net external costs	-244.0
Additional taxes paid	3,168.2
Pension plans	1,417.4
Total net transfers	4,341.5

Note: Due to rounding, total may differ.

2/ From the 'life-and-death' model, we also know, for each year after 1986, how many deceased smokers would have been alive and over 65 years old had they not smoked. To determine how much they would have received from each type of pension plan, it is sufficient to multiply their number, first, by the proportion of those 65 and over receiving money from that particular plan and, second, by the average amount of benefit paid out.

Taking the present value of the differences between additional contributions and benefit payments for each relevant year after 1986, we arrive at $2 billion. This is the amount that would have been necessary in 1986 to guarantee that the deceased smokers would benefit from pension plans exactly as non-smokers. Since smokers would participate in gathering this sum, only part of it is a transfer to non-smokers. Using once again the proportion of Canadian taxpayers who did not smoke in 1986 (69.15%), a transfer of $1.4 billion was obtained.[26]

The Net Transfer

If we sum the transfers over the three categories above, we get Table 5.

From our assumptions and the above analysis, it emerges that any notion that smokers are a burden on society in general or on the non-smoking population in particular is without foundation. Actually, for 1986 in Canada, non-smokers enjoyed a standard of living $4.3 billion higher than it would have been if there had been no smokers at all, according to our assumptions and methodology.

V Methodological Issues

Our results differ very considerably from the conclusions reached by several authors, including those who examined the Canadian situation.

These major differences come mainly from the methodology used and involve a number of considerations that may or may not be held relevant to the analysis of the financial burden of smokers on society.

There are three major issues: 1/ the reduction of future costs associated with the assumed early deaths of smokers; 2/ the notion of financial transfers between smokers and non-smokers; and 3/ finally, the most important one, the inclusion or exclusion of personal income losses in the balance sheet.

The Reduction of Future Costs

Although E.R. Shillington (1977) and N. Collishaw and G. Myers (1984) ignored the reduction of future healths costs, we maintain that these savings must be deducted from the supplementary costs associated with smoking. It is a matter of very simple logic to argue that if smokers die earlier than non-smokers, between the time of their early death and the time they would have died had they not smoked they will not use the services typically used by non-smokers. In any case, in approaching the problem in this way one may claim the support of several authors, such as A.B. Atkinson and J.L. Townsend (1977), W.F. Forbes and M.E. Thompson (1983), G.T. Watts (1983), R.E. Leu and T. Schaub (1983, 1984), and A. Markandya and D.W. Pearce (1989).[27]

In dollar terms, this item is not crucial, but it is not negligible either. As already indicated above, it reduces tobacco-related health cost by $462 million.

Transfers

Financial transfers between smokers and non-smokers are not considered in the ref-

erence studies cited above. In our view, such transfers, which determine who pays and who benefits between smokers and non-smokers respectively, are an essential component in any assessment of the burden that smokers may or may not impose on society.

There are two steps in such an analysis. First, one must incoporate taxes paid by smokers, because on efficiency grounds alone and consistent with the Pigovian approach, such taxes are a compensation for the external costs generated. An optimal tax in this context is one that just equals this external cost at the margin. Up to this point we follow A.B. Atkinson and T.W. Meade (1974), as well as A. Markandya and D.W. Pearce (1989). However, we make a second, additional, step in this study. As the calculations above indicate, total external costs and taxes are adjusted by the relevant proportions of smokers to derive transfers in the strict sense of the word.

We take a broad view of transfers as it should be. In addition to the taxes on tobacco consumption, our transfers include estimates of the net flow of pension contributions and benefits between smokers and non-smokers. The bottom line on overall transfers is given in Table 5.

Own Income Losses

Personal income losses are the main emphasis in most of the literature on the 'economic consequences' (cost) of smoking. For example, personal income loss represents 86 per cent of the 'economic consequences' in the study by Shillington (1977); 77 per cent in Collishaw and Myers (1984); and 55 per cent in USDHHS (1990). It seems that all these were inspired more or less directly by D.P. Rice (1966).

The concept of 'economic consequences' was renamed 'economic cost' by Leu (1983), and Leu and Schaub (1984), who rationalised it as the sum of the 'monetary private costs' to smokers plus the 'monetary external costs' of smoking. The 'economic cost' of smoking would then be the sum of its private and external components – that is, its social cost – but without considering intangible costs such as pain and suffering.

It is this concept of 'economic cost' that has been applied to show what a burden smokers are to society. The language used in the Report to Congress, USDHHS (1990), is unambiguous when the authors refer to 'the cost or value to society' (p.38) or when they remark that 'smoking causes large numbers of deaths and a very large dollar cost to society' (p.40).

Ultimately, it is suggested that taxes on tobacco should compensate for this huge burden. As we remarked in the introduction, there are numerous published opinions to this effect.

The fundamental issue to consider in this case is whether own-income losses associated with the premature death of smokers are a private cost or an external cost. Our thesis is that such income losses are a private cost and should not be included in an analysis of the financial burden of smokers on society.

The first argument in support of this thesis has been included earlier as one of our three basic assumptions in this study, namely that smokers behave rationally and are well-informed of any possible health hazard from smoking.

It might still be argued, however, that even though smokers have knowingly accepted the risk of sickness or early death, they nevertheless impose a loss on society. This evokes the image of smokers dying in their forties and thereby depriving society of another two decades of productive work. Such reasoning may seem persuasive, but it is almost invariably in error.

In fact, society tends to reward individuals strictly in accordance with the contribution it receives from each. It therefore neither gains nor loses with the increase or decrease of its overall numbers. When another worker is introduced into the economy, production rises, leading to the growth of national product. But this does not imply that society as a whole is any more rich or prosperous.

This reasoning is not new or original.

Indeed, there is a strong consensus among economists on this point. In the words of E.J. Mishan (1971a):

> the loss of potential future earnings, can be rationalized only if the criterion adopted in any economic reorganization turns on the value of its contribution to GNP, or, more accurately, to net national product. But although financial journalists manage to convey the contrary impression, maximizing GNP is not an acceptable goal of economic policy.

Mishan's judgment highlights the simple truth that the real victim of a death is the dead person concerned, not society as a whole.

The three methodological issues just raised are largely responsible for the huge differences between our empirical results and those of our reference studies. The myth and reality of the financial burden of smokers do not rest on the minute details of computations but on the relevant factors to be considered in the analysis. The next section will confirm this conclusion.

VI Sensitivity of Results to Relative Risk Coefficients

Remembering that our results regarding health costs are based on epidemiological studies which differ widely in their findings, a legitimate question arises about the sensitivity of our conclusions to the relative risk coefficients used. All calculations have therefore been done again using 14 different hypotheses covering a very wide range of possible assumptions regarding relative risk coefficients. They range from smoking is not dangerous at all ($\gamma = 0$), to smoking is ten times more dangerous than in the worse scenario envisaged in the reports we used ($\gamma = 10$).

As expected, gross external costs increase with the danger smoking poses to health. When γ equals 0, tobacco use is harmless to health, and the only external cost is fire at $54 million. When γ equals 1, relative risk coefficients being identical to those assumed in section II, we get the same result as in section III, of $668.8 million. Afterwards, costs tend to stabilize toward an upper bound which cannot be exceeded: obviously, when $\gamma \to \infty$, all the etiologic fractions tend to 100 per cent, at which point no further costs are left to be imputed.[28]

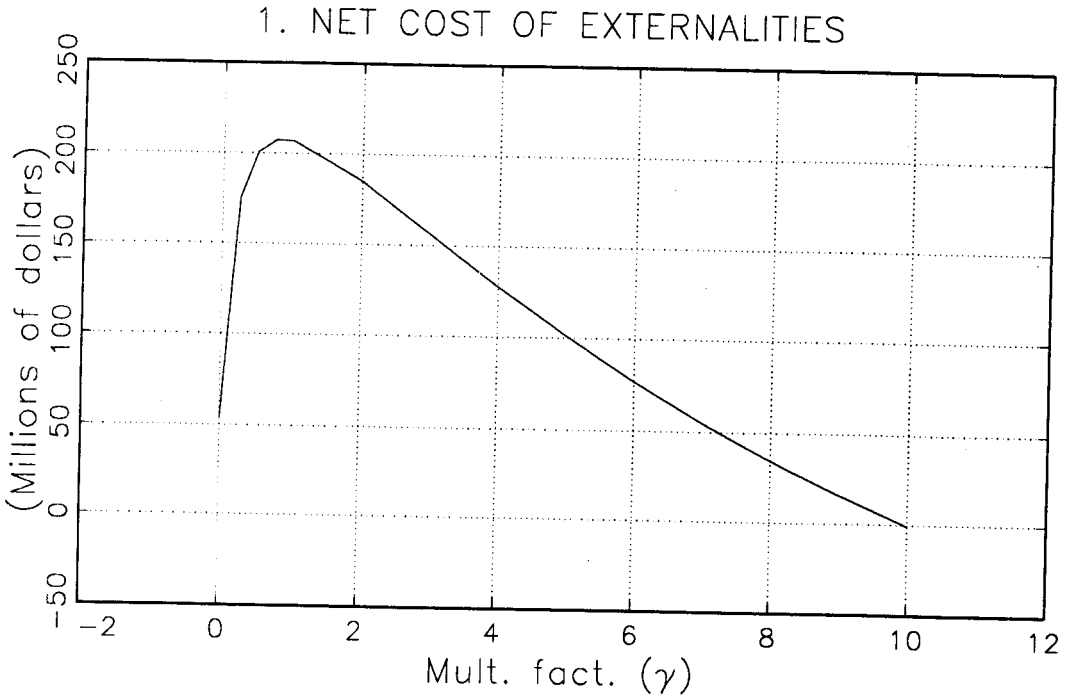
On the other hand, when smoking is harmless, there is no reduction in future costs; however, as it becomes increasingly dangerous, it is accompanied by a reduction in future costs. Two characteristics are worth noting: first, the curve describing the reduction in future costs increases at a lower rate than the additional cost curve does; and second, the rate of increase of the reduction cost curve decreases more slowly than the additional cost curve does.

These characteristics result in a very interesting net external cost curve, shown on Graph 1, which represents the difference between gross external costs and reduction of future costs.

It will be recalled that in our reference scenario, where γ equals 1, smokers imposed a net external cost of $207 million on Canadians in 1986. As is apparent from Graph 1, this net external cost appears to be in the neighbourhood of a maximum: whatever the relative risk coefficients one chooses, the net external cost is never significantly higher than $207 million. Reducing the risk brings a movement to the left of 'γ equals 1' and leads to a decline in net external cost, but increasing the risk, although it brings a movement to the right, also leads to a decline in net external costs because the reduction in future costs grows at a faster rate than the increase of additional costs in present value (as of 1986).

Actually, if it were possible for relative risk coefficients to be as high as when γ equals 10, we would have to conclude that there would be a net external benefit of $725,000 (which appears close to zero in Graph 1).

The existence of this maximum of approximately $207 million, allows us to observe that, whatever the risk smoking poses to health, the present level of taxation is un-



Graph 1

justifiable on grounds of efficiency. In other words, since the net external cost function is not an increasing monotonic function of the risk involved in tobacco use, there is no level of danger at which the present level of taxation would be justified.

As for the transfer between smokers and non-smokers, whatever the danger tobacco might pose to health, non-smokers always enjoy a much higher standard of living because of smokers. Given our assumptions, smokers are never a burden to non-smokers: at worst, non-smokers receive approximately $3 billion from smokers, and at best $7 billion. Without doubt, the net global transfer flow is always to the advantage of non-smokers and to the detriment of smokers.

VII Conclusion

At the beginning of this paper, we noted that many authors evaluated the 'economic consequences' of smoking as one huge sum, which has subsequently been interpreted as a burden smokers would be imposing on others. New taxes have been proposed and justified on these grounds.

We have shown instead that net additional external costs borne by non-smokers worked out to $244 million for Canada in 1986. However, smokers are responsible for a much larger transfer flow in the other direction. In the pension area alone, non-smokers benefit from a transfer of $1.4 billion mainly because smokers tend to die before non-smokers do if we use risk coefficients established by the medical profession. Finally, the massive tax burden borne by smokers alone means that they account for a further transfer of close to $3.2 billion to the benefit of non-smokers. Overall, as Table 5 indicates, smokers make a net overall contribution of $4.3 billion to the benefit of non-smokers.

Whatever the degree of risk or danger attributed to tobacco, the validity and direction of these conclusions remain unchanged.

Notes

1 See Forbes and Thompson (1978), Wilkinson et al. (1978), Heins (1978), Kristein and Grove (1978), Cady (1983), Warner (1983), Cady (1986) and Hoffenberg (1988). Studies on the 'economic consequences' of smoking such as those of Shillington (1977), Collishaw and Myers (1984) and the US Department of Health and Human Services (USDHHS, 1990), have been interpreted as implying a financial burden on the part of smokers. Strictly speaking, this implication is incorrect. See also Rice (1966), Stoddart (1987), Choi and Nethercott (1988), Freour et al. (1976), Luce and Schweitzer (1978), Shultz (1985), Hinds (1986), Gorsky, Schwartz and Dennis (1990), Gray et al. (1988). A closely related literature claims to follow 'cost-benefit' analysis. A typical example is found in Forbes and Thompson (1982), and a criticism in Woodfield (1984).

2 We used the Reports of the years 1982, 1983 and 1984. For a Canadian study, taking our relative risk coefficients from an American source may appear to be a second best, especially if one believes, as we do, that geographical variables may be important. However, some Canadian studies are included in these reports.

3 Although we did not review the medical literature systematically, we did come across some very disturbing findings for the 'conventional wisdom' about cigarette smoking and health. These lead us to believe: first, that the results of epidemiological studies might very well be strongly biased by the omission of some crucial variables from the statistical analyses, such as personality (especially risk aversion) which is responsible for a larger set of detrimental behaviours as well as beneficial ones, like exercising; and second, that adequate care had not always been taken in building the samples used in epidemiological studies. See Seltzer (1989 and 1980), Sterling and Weinkam (1987), and Tollison (1986).

4 We assume implicitly that the morbidity risk coefficients are the same as the mortality risk coefficients, because the statistics required to distinguish the two are inadequate. This assumption is not favourable to our conclusions.

5 Prospective studies are based on a random sample of individuals who are monitored over a number of years to determine how many among them will die of a lung cancer and were subject to smoke. Retrospective studies by contrast examine, ex-post, people who have died of a lung cancer and seek to determine how many among them were subjected to smoke. A retrospective study does not give a relative risk coefficient (ψ), strictly speaking, but an approximation of it (ψ').

6 Our emphasis in the text.

7 We do not deny that for those who are already victims of chronic obstructive lung disease, smoke could be the cause of some discomfort. We do not deny either that some people may complain of minor eye irritations, and the like, if they stay long enough in a room filled with thick smoke. However, what we do hypothesize is that it is far from established that someone can contract a disease requiring significant health care only because of environmental tobacco smoke. Later, we will explain why we do not evaluate the sums non-smokers would be willing to pay to avoid such inconveniencies.

8 See also Chaloupka (1990), and Becker, Grossman and Murphy (1990).

9 For further details on epidemiologic methods see Miettinen (1972, 1974), and Walter (1975; 1976).

10 Preliminary data for 1985–1986, from the Canadian Health Information Center. These data will be revised and published in the catalogue 82-206 (Statistics Canada, forthcoming b).

11 The average cost per day is taken from preliminary data from the Canadian Health Information Center. Once revised, it will be published in table 117 of the catalogue 83-233 (Statistics Canada, forthcoming a) for the year 1986–1987.

12 See Saskatchewan Cancer Foundation (1987:25), and Saskatchewan Health, Medical Care Insurance Branch (1989).

13 Marginal cost and benefit are increments. Usually we assume these increments to be small. However, in the present circumstances, we have no choice but to take the total cost as if it were an increment over 0.

14 Appendixes are available from the authors upon request. Appendix 1 gives the number of deaths according to cause and sex. It also describes the model which simulates what would have been the life and death of smokers had they not smoked and lived longer. Appendix 3 discusses the discrepancy between our 21,841 estimate of the number of deaths due to smoking and that of 35,131 from Collishaw, Tostowaryk and Wigle (1988).

15 From 1946 to 1990, the ex post real rate of return on 10-year Canadian bonds was never higher than 3%, except once in 1989. Indeed, it has been almost nil or even negative for approximately two decades, from the end of the 40s to the end of the 50s, and from the mid-'70s to the mid-'80s. Thus, over the long run, it is reasonable to believe that the maximum real rate of return on risk-free assets is not superior to 3%. Obviously, the discount rate could be inferior, but then, our conclusions would be even more favourable to smokers.

16 Additional medical services costs were found to be $68 million compared to $546.5 million for additional hospital care costs which gives a ratio of one to eight. We will find in the following section that the reduction of future medical services costs is $123.5 million. Applying the ratio of one to eight

would lead us to think that the reduction of future hospital care costs could be as high as $988 million.

17 We took as a reference the average costs as calculated by Régie de l'Assurance Maladie du Québec (1987). We made two adjustments: one to reconcile the average payments on a fee-for-service basis with overall medical services, and one to reconcile the per capita medical service cost in Quebec with that in Canada.

18 During 1986, the total number of old age recipients of residential care was established at 155,381. Assuming linear progression, this figure is derived from an interpolation carried out for June 1, between the March 1, 1986, figure of 154,502 (see Statistics Canada, 1989a) and the 158,019 figure of March 1, 1987, (see Statistics Canada, 1989b:119). The breakdown of this figure by age-group was performed according to table 6 in (Statistics Canada, 1989a).

19 We first found that public sources account for 65% of the residential care facilities income by substracting private financial sources (co-insurance, $539 million; supplements for rooms, $26 million; miscellaneous income, $46 million) from a total income of $1.73 billion (Table 9 of Statistics Canada, 1989a). We then took 65% of the average daily cost of $54.40 (Statistics Canada, 1989b:119), to obtain $35.17.

20 In an appendix, which is available from the authors upon request, we explain how we obtained the number of taxpayers among the smokers who would have survived between 1986 and 2071 had they not smoked.

21 This estimate is for calendar year 1986, and has been supplied by the Department of Finance, Government of Canada.

22 The estimates of the federal excise tax as well as the federal excise duty apply to fiscal year 1986–1987 and come from the Public Accounts (Canada, 1986).

23 The estimate of the tariff duty applies to the calendar year and comes from Statistics Canada (1986).

24 The figure published originally was $1,987.7 million. This figure was increased to include revenues from the general sales tax on tobacco in Newfoundland and Ontario.

25 The breakdown is as follows: $13,234,590 for Old Age Security and Supplement; $7,394,088 for Canada and Quebec Pension Plans; and, $8,832,962 for private pension plans.

26 Although this approach based on averages is quite rough, it still requires more than 250 tables, which shows that a more precise estimation would have required a study of its own. Detailed calculations would certainly have to take into account the changes in the number and age distribution of beneficiaries, of spouse's allowances and of pensions to survivors. As well, it would be necessary to calculate the change in the amounts paid out because a member of a couple dies. But, since the average income between men and women differs, it would also be necessary to take into account that the amount offered by some programs depends on general income and on other benefits already being paid out.

27 Leu and Schaub (1983), have been criticized by Forbes and Thompson (1985). A reply may be found in Leu and Schaub (1985).

28 The form of the curve does not depend on the transformation function, which is linear, but on the etiologic fraction function (see section III). More precisely, the higher the Euclidian norm $\| \psi \|$, the higher will be the first derivative of the cost function (which is positive) and the higher will be the absolute value of the second derivative (which is negative).

References

Atkinson, A.B. and T.W. Meade (1974) 'Methods and preliminary findings in assessing the economic and health services consequences of smoking, with particular reference to lung cancer,' *Journal of the Royal Statistical Society*, Part 3:297–312.

Atkinson, A.B. and J.L. Townsend (1977) 'Economic aspects of reduced smoking,' *Lancet*, 3:492–4.

Bartlett, L. (1988) 'Smoking: we cannot afford the cost,' *Canadian Medical Association Journal*, 138:644–5.

Becker, G.S., M. Grossman and K.M. Murphy (1990) 'An Empirical Analysis of Cigarette Addiction.' Center for the Study of the Economy and the State Working Paper 61. University of Chicago, Chicago.

Becker, G.S. and K.M. Murphy (1988) 'A Theory of Rational Addiction,' *Journal of Political Economy*, 96:675–700.

Bonilla, C.E. (1989) *Determinants of Employee Absenteeism*. Washington: US Chamber of Commerce, National Chamber Foundation.

Cady, B. (1986) 'Payment by Nonsmokers for Smoking-Related Illness,' *Journal of the American Medical Association*, 256:10:1291.

—— (1983) 'Cost of Smoking,' *New England Journal of Medicine*, 308(18):1105.

Canada (1986) *Public Accounts 1986–1987* (Ottawa).

Canadian Tax Foundation. (1986–87) *The National Finances* (Toronto).

Chaloupka, F.J. (1990) 'Rational Addictive Behavior and Cigarette Smoking.' National

Bureau of Economic Research Working Paper 3268. Cambridge, MA.
Choi, B.C.K. and J.R. Nethercott (1988) 'The Economic Impact of Smoking in Canada,' *International Journal of Health Planning and Management*, 3:197–205.
Collishaw, N.E. and G. Myers (1984) 'Dollar Estimates of the Consequences of Tobacco Use in Canada, 1979,' *Canadian Journal of Public Health*, 75:192–9.
Collishaw, N.E., W. Tostowaryk and D.T. Wigle (1988) 'Mortality Attributable to Tobacco Use in Canada,' *Canadian Journal of Public Health*, 79:166–9.
Forbes, W.F. and M.E. Thompson (1978) 'Cigarette Smoking: Medical Costs vs Tax Receipts,' *Journal of the American Medical Association*, 240:9:828.
—— (1982) 'Costs and "benefits" of cigarette smoking in Canada,' *Canadian Medical Association Journal*, 127:831–2.
—— (1983) 'Estimating the Health Care Costs of Smokers,' *Canadian Journal of Public Health*, 74:3:183–90.
—— (1985) 'Reasons for the Disagreements on the Impact of Smoking on Medical Care Expenditures: A Proposal for a Uniform Approach,' *Social Science and Medicine*, 21:7:771–3.
Freour, P. et al. (1976) 'Le coût du tabagisme en France,' *Bulletin de l'Académie Nationale de Médecine*, 160:6:583–91.
Gorsky, R.D., E. Schwartz and D. Dennis (1990) 'The morbidity, mortality, and economic costs of cigarette smoking in New Hampshire,' *Journal of Community Health*, 15:3:175–83.
Gray, A.J. et al. (1988) 'The cost of cigarette smoking in New Zealand,' *New Zealand Medical Journal*, 101:844:204–7.
Health and Welfare Canada (HWC) (1988) *The Smoking Behaviour of Canadians – 1986* (Ottawa: Supply and Services Canada).
—— (forthcoming) Table 6 from *National Health Expenditures in Canada 1975–1987.*
Heins, M. (1978) 'Health Costs of Alcohol and Tobacco: Who Pays?' *New England Journal of Medicine*, 298.
Hinds, M.W. (1986) 'Medical Care Costs Attributable to Cigarette Smoking in Kentucky,' *Southern Medical Journal*, 79:6:665–8.
Hoffenberg, R. (1988) 'Penalising Smokers and Drinkers,' *Lancet*, 1:8586:649.
Kristein, M.M. and D.A. Grove (1978) 'Who Pays Health Costs of Alcohol and Tobacco?' *New England Journal of Medicine*, 299:606–7.
Labour Canada (LC) (1987) *Report of the Dominion Fire Commissioner, Annual report 1986 – Losses caused by fires in Canada* (Ottawa).
Leu, R.E. (1983) 'What Can Economists Contribute?' In M. Grant M. Plant and A. Williams (eds.), *Economics and alcohol* (London: Croom Helm).
—— and T. Schaub (1983) 'Does Smoking Increase Medical Care Expenditure?' *Social Science and Medicine*, 17:1907–14.
—— (1984) 'Economic Aspects of Smoking,' *Effective Health Care*, 2:3:111–23.
—— (1985) 'More on the Impact of Smoking on Medical Care Expenditures,' *Social Science and Medicine*, 21:7:825–7.
Luce, B.R. and S.O. Schweitzer (1978) 'Smoking and Alcohol Abuse: A Comparison of their Economic Consequences,' *New England Journal of Medicine*, 298:10:569–71.
Markandya, A. and D.W. Pearce (1989) 'The social costs of tobacco smoking,' *British Journal of Addiction*, 84:1139–50.
Miettinen, O.S. (1972) 'Components of the crude risk ratio,' *American Journal of Epidemiology*, 96:2:168–72.
—— (1974) 'Proportion of disease caused or prevented by a given exposure, trait or intervention,' *American Journal of Epidemiology*, 99:5:325–32.
Mishan, E.J. (1971a) *Cost-Benefit Analysis* (London: Allen & Unwin).
—— (1971b) 'Evaluation of life and limb: a theoretical approach,' *Journal of Political Economy*, 79:4:687–705.
—— (1981) 'The value of trying to value a life,' *Journal of Public Economics*, 15:1:133–37.
Petawawa National Forestry Institute (PNFI) (1989) *Unpublished tables* (Chalk River: Forestry Canada).
Régie de l'Assurance Maladie du Québec (RAMQ) (1987) *Statistiques annuelles 1986* (Québec: Service des communications de la RAMQ).
Rice, D.P. (1966) *Estimating the Cost of Illness.* Health Economic Series No 6. (Washington: US Department of Health, Education and Welfare, Public Health Service).
Saskatchewan Cancer Foundation (1987) *Annual Report 1986–1987.* Regina.
Saskatchewan Health, Medical Care Insurance Branch (1989) *Totalisation spéciale: coût des services médicaux suivant les codes de maladies 410 à 414 et 490 à 496.*
Seltzer, C.C. (1980) 'Smoking and Coronary

Heart Disease: What Are We to Believe?' *American Heart Journal*, 100:275–80.
—— (1989) 'Framingham Study Data and "Established Wisdom" About Cigarette Smoking and Coronary Heart Disease,' *Journal of Clinical Epidemiology*, 42:8:743–50.
Shillington, E.R. (1977) *Selected Economic Consequences of Cigarette Smoking* (Ottawa: National Ministry of Health and Welfare).
Shultz, J.M. (1985) 'Perspectives on the Economic Magnitude of Cigarette Smoking,' *New York State Journal of Medicine*, 85:7:302–6.
Statistics Canada (1986) *Imports, merchandise trade – 1986*. Cat. 65-23 (Ottawa).
—— (1988) *Age, sex and marital status*. Cat. 93-101 (Ottawa).
—— (1989a) *Residential care facilities for the aged*. Cat. 83-237 (Ottawa).
—— (1989b) *Health Reports*. Cat. 82-003 Quarterly (Ottawa).
—— (forthcoming a) Table 117 of Cat. 83-233.
—— (forthcoming b) Table 1 of Invoice 41017 (Formerly Hosp. Morb.) Cat. 82-206.
Sterling, T.D. and J.J. Weinkam (1987) 'Errors in Estimates of Smoking-Related Deaths Derived from Nonsmoker Mortality,' *Risk Analysis*, 7:4:463–75.
Stoddart, G.L. et al. (1986) 'Tobacco Taxes and Health Care Costs: Do Canadian Smokers Pay Their Way?' *Journal of Health Economics*, 5:63–80.
Sullivan, P. (1989) 'Make it too costly for people to smoke, finance minister advised,' *Canadian Medical Association Journal*, 140:5:546.
Tollison, R.D. (1986) *Smoking and Society, Toward a More Balanced Assessment* (Toronto: Lexington Books).
US. Department of Health and Human Services (USDHHS) (1982) *The Health Consequences of Smoking: Cancer*. A Report of the Surgeon General (Washington: Superintendent of Documents, US Government Printing Office).
—— (1983) *The Health Consequences of Smoking: Cardiovascular Disease*. A Report of the Surgeon General (Washington: Superintendent of Documents, US Government Printing Office).
—— (1984) *The Health Consequences of Smoking: Chronic Obstructive Lung Disease*. A Report of the Surgeon General (Washington: Superintendent of Documents, US Government Printing Office).
—— (1986) *The Health Consequences of Involuntary Smoking*. A Report of the Surgeon General (Washington: Superintendent of Documents, US Government Printing Office).
—— (1990) *Smoking and Health, A National Status Report*. A Report to Congress. Publication No. (CDC) 87-8396 (Washington: DHHS).
Viscusi, W.K. (1990) 'Do Smokers Underestimate Risks?' *Journal of Political Economy*, 98:6:1253–69.
Walters, S.D. (1976) 'The estimation and interpretation of attributable risk in health research,' *Biometrics*, 32:828–49.
—— (1975) 'The distribution of Levin's measure of attributable risk,' *Biometrika*, 62:2:371–75.
Warner, K.E. (1983) 'The Economics of Smoking: Dollars and Sense,' *New York State Journal of Medicine*, 83:13:1273–4.
Watts, G.T. (1983) 'Cost of smoking,' *New England Journal of Medicine*, 309:15:929.
Wilkinson, R. et al. (1978) 'Health Costs of Alcohol and Tobacco: Who Pays?' *New England Journal of Medicine*, 298:22:1262–3.
Woodfield, A.E. (1984) 'Costs and "benefits" of cigarette smoking in Canada: comment,' *Canadian Medical Association Journal*, 130(2):118–20.