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Smoking and Healthcare and Welfare Costs. A Cohort Study.

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Abstract

Objective: To study the net economic effect of smoking on society.

Design, Setting, and Patients: We studied mortality, paid income and tobacco taxes, and the cumulative costs due to pensions and medical care among both tobacco smoking and non-smoking individuals in a 27-year prospective cohort study of 1,976 men from Eastern Finland. These individuals were 54–60 years old at the beginning of the follow-up.

Main Outcome Measures: The net contribution of smoking vs. non-smoking individuals to public finance balance (euros).

Results: Smoking was associated with a greater mean annual health care cost of €1,600 per living individual during follow-up. However, due to a shorter life span of 8.6 years, smokers' mean total healthcare costs during the entire study period were actually €4,700 lower than for non-smokers. For the same reason, each smoker missed 7.3 years (€126,850) of pension. Overall, smokers' average net contribution to the public finance balance was €133,800 greater per individual compared with non-smokers. However, if each lost quality adjusted life year is considered to be worth €22,200, the net effect is reversed to be €70,200 per individual in favour of non-smoking.

Conclusion: Smoking was associated with a moderate decrease in health care costs, and a marked decrease in pension costs due to increased mortality. However, when a monetary value for life years lost was taken into account, the beneficial net effect of non-smoking to society was about €70,000 per individual.

Introduction

Smoking is the single most important preventable cause of premature death in industrialized countries[1], and tobacco taxation is still the most cost-effective method for decreasing the prevalence of smoking. Increases in tobacco taxes have encouraged 9 to 17% of smokers to quite[2,3], and in the long run the main effect of taxation is a reduction in the incidence of new young smokers.[4] Early smoking cessation increases lifespan by about 9-10 years,[5] and if the smoking rate diminished by 10 percentage points, life expectancy would increase by about one year. It has been estimated that a 10% increase in the price of smoked tobacco will result in about a 5% decrease in cigarette consumption,[4] yet tobacco taxes are still low in many countries. Thus, it would be interesting to know why so many governments in the world continue to increase spending on health care costs, while a substantial savings and advances in life expectancy are readably available by administratively increasing tobacco taxes? There are two plausible explanations: the governments do not know about the correlation between increasing tobacco taxes on increasing life expectancy, or they realize this effect, but do not want to increase the life expectancy.

The net effect of smoking on healthcare costs has been investigated in several studies.[6-16] Some modelling studies have suggested that while smokers suffer more from many kinds of diseases, non-smokers incur more healthcare costs because they live longer,[6,7,8,11,12] yet others have reached the opposite conclusion.[9,10,13-16] Only two of these studies have included both pension and insurance costs,[7,12] and only one study has included paid tobacco taxes.[12] In 2001, Philip Morris provided a report to the Government of the Czech Republic, which indicated that the effect of smoking on the public finance balance in the Czech Republic in 1999 was positive and estimated to be 5,815 million korunas (about 150 million USD).[12] Although this report generated outraged reactions worldwide, Milos Zeman, the Czech prime minister stated “As a smoker, I support the state budget, because in the Czech Republic, we pay tax on tobacco. Also, smokers die sooner, and the state does not need to look after them in their old age”. [17,18] To our knowledge, the Philip Morris report is the only published study thus far on the overall effect of smoking on the balance of public finance. This report was based on many assumptions that were obtained through theoretical modelling, and it did not give any monetary value for life years lost because of

smoking, and it was claimed to have underestimated the costs of medical care for people suffering from smoking related diseases.[19] As shown by van Baal et al., slightly different models can give markedly different results on the net effect of smoking, depending what assumptions are used[20]. In any case, sophisticated incidence-based datasets are ultimately required to establish the true health care costs incurred by smoking.[21] Because no results have been obtained from empirical data based on mortality, morbidity, pension and health care costs, the net economic impact of smoking on society has remained unclear. The aim of this study was to investigate this net economic effect by using data from a prospective 27-year follow-up of a cohort of 1,976 Finnish middle-aged men.

Methods

Study population

The subjects of the Kuopio Ischemic Heart Disease study (KIHD) were obtained from a randomly selected sample of 3,433 men, aged 42 to 60 years, who resided in the town of Kuopio or its surrounding rural communities. Of those invited, 2,682 (83 %) participated in the study. Of these, individuals from 54 to 60 years with complete data for smoking, income, healthcare costs, retirement, and mortality (n=1,976 men) were included in the final analyses. The baseline examinations were conducted between March 1984 and December 1989.[22] The mean follow-up time was 24.2 years (range 21.1±26.8 years). The KIHD study was approved by the Research Ethics Committee of the University of Kuopio, in Kuopio, Finland. Each participant gave written informed consent. The end of follow-up period was December 31, 2010.

A subject was defined as a smoker if he had ever smoked on a regular basis, and had smoked cigarettes, cigars, or a pipe within the past 30 days. The lifelong exposure to smoking ("cigarette pack-years") was estimated as the product of years smoked and the number of tobacco products smoked daily at the time of examination. "Years smoked" were defined as the sum of years of smoking regardless of when smoking had started, whether the subject had stopped smoking, or whether it had occurred continuously or during several periods. Data on mortality was obtained from Statistics Finland, and data on healthcare costs from the Finnish Institute for Health and Welfare (THL). The health care

costs did not include visits to general practitioners, home nursing, or medication and dental care costs in outpatient care, which have been estimated to be about 20–30% of total health care costs in this age group in Finland.[23] The amount of paid tobacco taxes was estimated on the basis of cigarette pack-years,[24] and the amount of paid income taxes was estimated by using the income tax rate of year 1987. The amount of occupational productivity and income taxes lost was calculated as the difference of age at retirement (relative to the retirement age of matched non-smokers) multiplied by the annual income and income tax of each smoker. "Income taxes paid" also included obligatory pension and healthcare insurance fees. All monetary values were expressed as Euros (€) and converted to the level of year 2009.

In the United Kingdom, the monetary value of one quality adjusted life year (QALY) has been estimated to be 20,000–30,000 Pounds for an individual having perfect health.[25] In the present study, we used a value of 30,000 Euros (about 25,100 Pounds in February 2012). In a recent large study on the effect of smoking on life expectancy, the quality-of-life score among former smokers with a BMI of 25–30, who were older than 65-years was estimated to be 0.71–0.77.[26] Therefore, we used a quality-of-life score of 0.74 for smokers in the present study, thus equalling to 0.74 x 30,000 Euros = 22,200 Euros for each life year lost due to smoking among former smokers aged over 65 years (deceased smokers who would be over 65 if they had lived).

Statistical analysis

Differences in baseline characteristics and costs were examined using the Student's t-test. Descriptive data are presented as means and percentages. A p-value of less than 0.05 was considered statistically significant. These statistical analyses were performed using SPSS 17.0 for Windows. Life expectancy for those individuals still alive on 31st December 2009 was calculated by using life expectancy from the Life Table provided by Statistics Finland.[27]

Results

The crude mortality rates were 351/493 (71.2%) among smokers, and 553/1483 (37.3%) among non-smokers, and the cause-specific mortality in each group is shown in Table 1. The observed age at death was 67.8 years for smokers, and 71.4 years for non-smokers. The predicted mean age at death was 72.1 for smokers and 80.7 years for non-smokers, indicating 8.6 years difference between two groups. When the effect of birth year on life expectancy was taken into account, the amount of life years lost due to smoking was 9.2 years. The demographic variables and smoking-related outcomes are shown in Table 2. Smokers had substantially lower mean BMI and educational level. Smokers also had a slightly lower mean systolic blood pressure and a slightly higher mean LDL cholesterol level. Smoking was associated with a moderate decrease in productive occupational career, income taxes paid, and hospital care costs, and showed a marked decrease in pension costs. The net effect of smoking on public finance was plus € 133,800 for these smokers during the follow-up when life years lost were not included, and minus € 70,200 when a monetary value for life years lost was included in the calculation.

Figure 1 demonstrates the average annual healthcare costs as a function of age among those individuals still alive, and Figure 2 shows the corresponding results when all individuals (also deceased) are included. The higher mortality results into lower annual costs among smokers after 72 years from birth.

Discussion

Hospital care costs were 1,600 Euros greater per person year for living individuals among the smokers during the follow-up, but due to a 8.6 year shorter life span, the total costs per individual were 4,700 Euros lower among smokers than non-smokers during the entire study period. This study provides the first evidence for the net economic effect of smoking vs. non-smoking on costs related to health and social welfare, based on prospective empirical data.

Smoking resulted in a moderate decrease in the productive occupational career and income taxes and pension fees paid, a moderate decrease in health care costs, and a

marked decrease in the pension costs. The costs of smoking to society have been modelled by using estimates on increased mortality and morbidity.[6-16] However, none of these modelling studies investigated the overall net economic effect of smoking on public finance balance by using empirical data from individuals, or by taking into account all of the following factors; lifetime productivity or income taxes and pension fees paid, pension costs, and a monetary value of life years lost. Combined, these factors make considerable contribution to the overall net effect than merely health care costs. If the potential increase in quality adjusted life years is taken into account, our results suggest that the life long net beneficial economic effect of early smoking cessation is more than € 70,000 per individual. Our results also indicate that reducing the rate of smoking has a huge beneficial economic effect on society, mainly due to increased life span and continued pension costs. In Finland, the National Institute for Health and Welfare aims to make Finland free of smoking by the year 2040. Since there are currently about 900,000 smokers in Finland, the average net effect of € 134,000 per individual on public finance balance (without taking into account the monetary value of life years lost) would correspond during the next decades to about 120 billion Euros total increase in costs (over 2.5-fold to annual state budget). However, this nominal deficit would be massively outweighed by about 2 years increase in life expectancy of the whole nation.

The only other study that has considered the effect of lost productivity and paid tobacco taxes was by Arthur Little for Philip Morris in 2001.[12] Our overall results on the net economic effect of smoking on public finance balance are contrary to the Philip Morris report. A major reason for this difference is that Little did not consider the inherent value of the quality adjusted life years lost. In other words, if we used an estimate of 0 Euros for each lost year of human life, then the positive economic effect of smoking in our study would have been even larger than the effect estimated by Little. However, when considering the implications of these results, the major question is whether or not humans are to bevalued as commodities, like domesticated animals, or does human life maintain an inherent value even when the individual is not longer economically productive, as in retirement? In the field of health care, it is generally assumed that all human life – even that of the old and disabled – is precious and has value. This view is also currently accepted by national authorities throughout most of the modern world. Already in 1999, 387 billion USD was used in the U.S. for medical treatment and care of people older than 65 years.[28] Nowadays it is generally agreed that the monetary value of one additional life

year of a healthy human being is about 20,000-30,000 British Pounds when additional costs of medical care are considered.[25] One may ask why societies continue to invest even larger amounts of money and other social resources to achieve a longer mean life span for citizens, while a more drastic increase could be achieved administratively, without any further costs, by substantially raising tobacco taxes and otherwise restricting access to smoking? There are two likely answers: either governmental authorities have not realized this fact, or they have realized it, but do not want to increase life expectancy due to a subsequent increase in both health care and pension costs.

While denying access to medical care for older people, in order to prevent a deficit in national economy, would not be possible because of common ethical concerns and public opinion, preventing a decrease in smoking rates essentially has the same effect, and is apparently more accepted by many societies. If this is the case, it would also explain the reluctance of governments to regulate the eating and other consumption habits of that negatively affect the general population by, for example, increasing the value added tax (VAT) on food products that are high in sugar and saturated fats, and decreasing VAT on fruits and vegetables, for example. The Czech prime minister stated in 2001 that smoking is beneficial for the state, because smokers die sooner.[17,18] Such comments have not been echoed by other state leaders since, however it is plausible that this view still influences tobacco policies in many modern countries. Therefore, governments should be transparent concerning which kind of knowledge their tobacco and food taxation policy is based on.

The strength of this study is based on empirical data that was gathered from a 27-year prospective study. Thus, no assumptions on healthcare, pension costs or discount percentages of future costs were needed. One shortcoming is that this study did not include females, and it did not include visits to general practitioners, home nursing, or medication and dental care costs in outpatient care, which contribute to about 20–30% of the total health care costs among elderly and middle aged people in Finland.[23] In a previous 19-year follow-up study, it was observed that while the overall healthcare costs were higher among smokers aged 25–59 years, the costs of medication in outpatient care did not differ between smokers and non-smokers.[29] Thus it can be further estimated that the total health care costs might have been at the most about 6,000 to 7,000 Euros higher per individual among non-smokers when compared with smokers, instead of our modest estimate of about 5,000 Euros per individual. However, the magnitude of this difference

(€ 1,000–2,000) is less than 2% of the pension costs, and does not have any substantial effect on these results. We also did not include the costs of fires or littering related to smoking, as this information was not available, yet the combined contribution of these factors is probably less than 1% of the total costs.[12] Since only 17% of the initiated subjects refused to participate, the generalisability of results can be considered quite sufficient.

It was presumed that smokers' lower education level and lower income level were not caused by smoking, and that differences in these characteristics were associated with smoking due to the fact that less educated individuals are more likely to start smoking than individuals with higher educational level. Therefore, it was assumed that smoking cessation would not substantially increase education level or income. It can be estimated that during a productive career of about 35 years, with an annual difference of € 2,970 in paid income taxes, smokers in our study have paid an average about 100,000 Euros less income taxes than non-smokers. If it were assumed that early smoking cessation would change these variables to the same levels as with non-smokers, the net difference between smokers vs. non-smokers would shift from € 134,000 to about € 30,000 in favour of smoking, if the value of life years lost are not included, and from € 70,000 to about € 170,000 in favour of non-smoking if the value of life years lost are included in the analysis. Either way, the principal conclusions on the net costs would remain the same. It is questionable if the tobacco taxes should be considered as beneficial increases in income to the state. For example, if an individual would not have been smoking, then he/she probably would have consumed more goods in the extra years of life and thus paid more taxes for those goods instead of the taxes paid for cigarettes. Overall, the estimate of a € 70,000 beneficial effect of early smoking cessation per individual is probably an underestimate.

Article summary

1) Article Focus

- No results have been obtained from empirical data based on mortality, morbidity, pension and health care costs and, therefore, the net economic impact of smoking on society has remained unclear.

2) Key Messages

- Both the healthcare and pension costs are lower for smokers than non-smokers, the overall difference being more than 100,000 euros per individual.
- However, when a monetary value for life years lost was taken into account, the beneficial net effect of non-smoking to society was about €70,000 per individual.

3) Strengths and Limitations

- This study provides the first evidence for the net economic effect of smoking vs. non-smoking on costs related to health and social welfare, based on prospective empirical data.
- Only males were included in study.

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Competing Interest: All authors have completed the Unified Competing Interest form at www.icmj.org.coi_disclosure.pdf (available on request from the corresponding author) and declare: Dr Tiihonen is a member of advisory board of AstraZeneca and Janssen-Cilag, and he reports serving as a consultant to Lundbeck, Organon, Janssen-Cilag, Eli Lilly, AstraZeneca, F. Hoffman-La Roche, and Bristol-Myers Squibb. He has received fees for giving expert opinions to Bristol-Myers Squibb and GlaxoSmithKline, and lecture fees from Janssen-Cilag, Bristol Myers-Squibb, Eli Lilly, Pfizer, Lundbeck, GlaxoSmithKline, Novartis, and Astra Zeneca. No further disclosures were reported.

Contributors: JT, KR and JK had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. JT wrote the first draft of the manuscript and all other authors read and had input in the final version of the paper. JT did study concept and design, KR and JK collected data, KR did statistical analysis and KR produced figures. JT is the guarantor.

Ethical approval: The KIHD study was approved by the Research Ethics Committee of the University of Kuopio, in Kuopio, Finland.

Data sharing: No additional data available.

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Figure legends

Figure 1. Average annual health care costs per living individual, in Euros, as a function of age.

Figure 2. Average annual health care costs among all individuals in Euros (including deceased persons).

Table 1. Cause-specific mortality among smokers and non-smokers.

Cause of death	Non-smokers (%)	Smokers (%)
Cardiovascular disease	267 (48%)	166 (47%)
Cancer (all)	146 (26%)	102 (29%)
Lung cancer	15 (3%)	47 (13%)
Respiratory disease	13 (2%)	20 (6%)
External causes of death	56 (10%)	28 (8%)
Other	71 (13%)	35 (10%)
Total	553 (100%)	351 (100%)

A total of 553 (37.3%) non-smokers and 351 (71.2%) smokers had died during the follow-up. Percentages indicate the proportions for cause of death from all deaths in each group. Cancer deaths include lung cancer deaths.

Table 2. Smoking-related outcomes.

	Non-smokers N=1483		Smokers N=493			
	Mean	S.D.	Mean	S.D.	Difference of means	p-value
Age at baseline, years	55.72	2.50	55.54	2.38	-0.2	0.17
Body mass index (BMI)	27.29	3.51	26.01	3.81	-1.3	< 0.001
Mean systolic blood pressure (mm Hg)	135.93	17.43	133.43	18.18	-2.5	0.007
LDL-cholesterol (mmol/l)	4.07	1.01	4.21	1.09	0.1	0.013
Years of education	8.19	3.32	7.52	2.74	-0.7	< 0.001
Age at death, years	80.71	8.40	72.13	8.89	-8.6	< 0.001
Life years lost due to smoking	0	0	9.19	8.15	9,2	< 0.001
Age at retirement, years	56.60	5.89	55.35	6.23	-1.3	< 0.001
Years of receiving pension	23.69	9.11	16.42	9.39	-7.3	< 0.001
Number of hospitalizations	10.74	12.34	10.84	10.89	0.1	0.88
Number of inpatient days	88.47	235.25	101.55	216.23	13.1	0.28
Years of smoking (at baseline)	2.69	8.96	31.81	9.72	29.1	< 0.001
Annual income, €	34,060	22,180	27,510	17.730	-6,550	< 0.001
Occupational productivity lost due to smoking, €	0	0	34,370	27,080	34,370	< 0.001
Income taxes lost due to smoking, €	0	0	11,660	12,550	11,660	< 0.001
Annual pension, €	20,440	13,330	16,180	9,730	-4,260	< 0.001
Reduced pension costs due to smoking,€	0	0	126,850	148,120	126,850	< 0.001
Reduced income taxes paid from pensions, €	0	0	34,230	48,650	34,230	< 0.001
Annual health care costs/living individuals, €	3,420	9,870	5,040	10,650	1,620	0.003
Total health care costs, €	79,290	173,420	74,570	154,950	-4,720	0.59
Tobacco tax paid, €	2,190	8,860	50,300	32,450	48,110	< 0.001
Life years lost due to smoking, €	0	0	203,960	180,890	203,960	<0.001
Total costs, life years lost not included, €	77,110	173,840	-56,680	195,130	-133,790	< 0.001
Total costs, life years lost included, €	77,110	173,840	147,280	195,960	70,170	<0.001

Total costs of smoking vs. non-smoking were calculated by taking into account the life-long difference (€/person) of health care costs (€ 4,720), tobacco taxes paid (€ 48,110), income taxes lost (€ 11,660), reduced pension costs (€ 126,850), and reduced taxes paid from pensions (€ 34,230). The smoking-related harms for the society were € 11,660 + € 34,230 = € 45,890, and the smoking-related benefits for the society were € 4,720 + € 48,110 + € 126,850 = € 179,680, and thus the net effect on public finance balance was € 133,790 positive for each smoking individual. When the value of 9.19 life years lost due to smoking (€ 203,960) was taken into account, the net effect became € 70,170 negative for each smoking individual. “Income taxes lost due to smoking” indicate the loss due to earlier disability/retirement, and “Pension costs” indicate the pensions paid by the state and pension companies. The value of one quality adjusted life year lost was estimated to be 0.74 x € 30,000 = € 22,200.[10,25]

Figure 1. Average annual health care costs per living individual, in Euros, as a function of age.

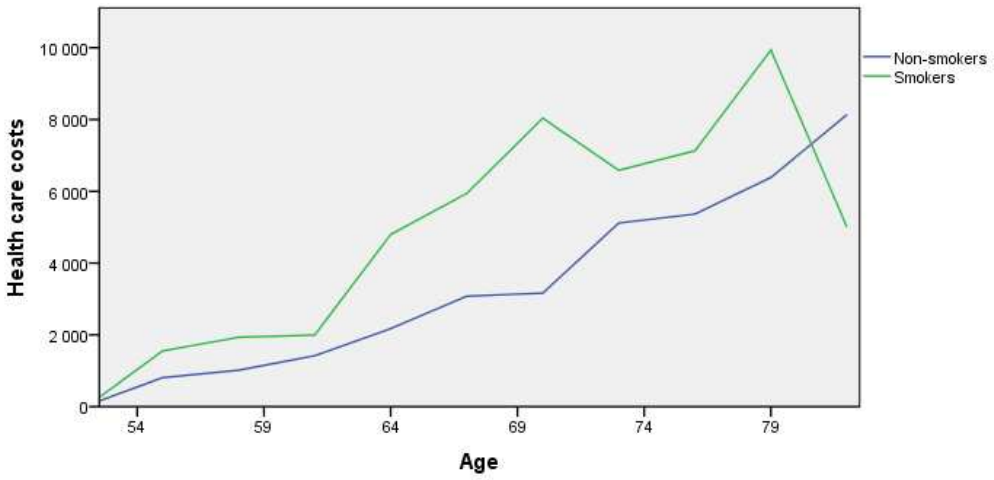
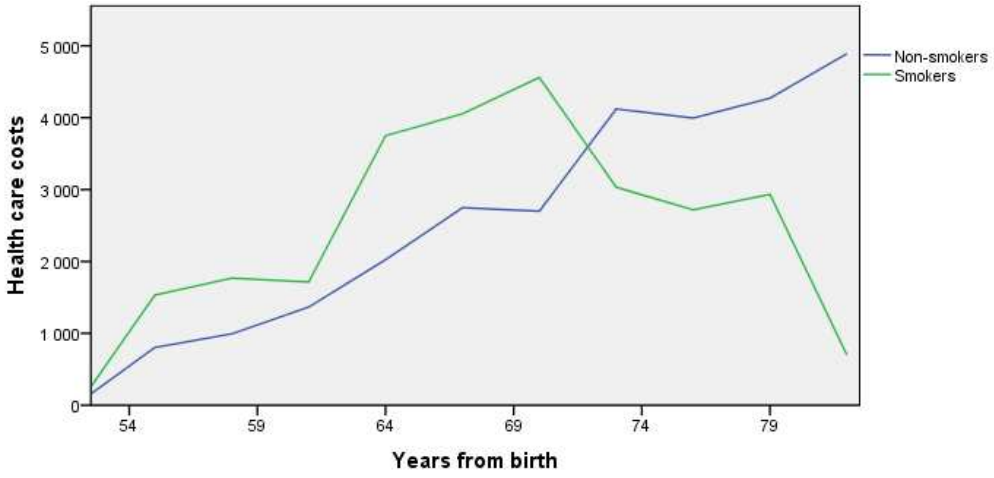


Figure 2. Average annual health care costs among all individuals in Euros (including deceased persons).



STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1 Done	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2 pp. 3,4	Explain the scientific background and rationale for the investigation being reported
Objectives	3 p. 4	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4 p. 4	Present key elements of study design early in the paper
Setting	5 p. 4	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 pp. 4,5	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7 pp. 4,5	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8* pp.4,5	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 Not done	Describe any efforts to address potential sources of bias
Study size	10 p. 4	Explain how the study size was arrived at
Quantitative variables	11 pp. 4,5	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 p. 5	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed No missing data
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13* p. 4	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage No drop-outs or missing data
		(c) Consider use of a flow diagram
Descriptive data	14* Done	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Table 2
		(b) Indicate number of participants with missing data for each variable of interest No missing data
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount) p. 4
Outcome data	15* Done	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures Tables 1 and 2
Main results	16 Done	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses No such analyses
Discussion		
Key results	18 pp. 6, 7	Summarise key results with reference to study objectives
Limitations	19 pp. 8, 9	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20 p. 9	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21 p. 9	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22 p. 11	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Smoking and healthcare and welfare costs. A Cohort Study.

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Smoking and Healthcare and Welfare Costs. A Cohort Study.

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Keywords: smoking; healthcare; costs; mortality

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Abstract

Objective: To study the net economic effect of smoking on society.

Design, Setting, and Patients: We studied mortality, paid income and tobacco taxes, and the cumulative costs due to pensions and medical care among both tobacco smoking and non-smoking individuals in a 27-year prospective cohort study of 1,976 men from Eastern Finland. These individuals were 54–60 years old at the beginning of the follow-up.

Main Outcome Measures: The net contribution of smoking vs. non-smoking individuals to public finance balance (euros).

Results: Smoking was associated with a greater mean annual health care cost of €1,600 per living individual during follow-up. However, due to a shorter life span of 8.6 years, smokers' mean total healthcare costs during the entire study period were actually €4,700 lower than for non-smokers. For the same reason, each smoker missed 7.3 years (€126,850) of pension. Overall, smokers' average net contribution to the public finance balance was €133,800 greater per individual compared with non-smokers. However, if each lost quality adjusted life year is considered to be worth €22,200, the net effect is reversed to be €70,200 (€ 71.600 when adjusted with propensity score) per individual in favour of non-smoking.

Conclusion: Smoking was associated with a moderate decrease in health care costs, and a marked decrease in pension costs due to increased mortality. However, when a monetary value for life years lost was taken into account, the beneficial net effect of non-smoking to society was about €70,000 per individual.

Introduction

Smoking is the single most important preventable cause of premature death in industrialized countries[1], and tobacco taxation is still the most cost-effective method for decreasing the prevalence of smoking. Increases in tobacco taxes have encouraged 9 to 17% of smokers to quite[2,3], and in the long run the main effect of taxation is a reduction in the incidence of new young smokers.[4] Early smoking cessation increases lifespan by about 9-10 years,[5] and if the smoking rate diminished by 10 percentage points, life expectancy would increase by about one year. It has been estimated that a 10% increase in the price of smoked tobacco will result in about a 5% decrease in cigarette consumption,[4] yet tobacco taxes are still low in many countries. Thus, it would be interesting to know why so many governments in the world continue to increase spending on health care costs, while a substantial savings and advances in life expectancy are readably available by administratively increasing tobacco taxes? There are two plausible explanations: the governments do not know about the correlation between increasing tobacco taxes on increasing life expectancy, or they realize this effect, but do not want to increase the life expectancy.

The net effect of smoking on healthcare costs has been investigated in several studies.[6-18] Some modelling studies have suggested that while smokers suffer more from many kinds of diseases, non-smokers incur more healthcare costs because they live longer,[6,7,8,11,12] yet others have reached the opposite conclusion.[9,10,13-18] Only few of these studies have included both pension and insurance costs,[7,12,17,18] and paid tobacco taxes.[12,17,18] In 2001, Philip Morris provided a report to the Government of the Czech Republic, which indicated that the effect of smoking on the public finance balance in the Czech Republic in 1999 was positive and estimated to be 5,815 million korunas (about 150 million USD).[12] Although this report generated outraged reactions worldwide, Milos Zeman, the Czech prime minister stated “As a smoker, I support the state budget, because in the Czech Republic, we pay tax on tobacco. Also, smokers die sooner, and the state does not need to look after them in their old age”. [19,20] This report was based on many assumptions that were obtained through theoretical modelling, and it did not give any monetary value for life years lost because of smoking, and it was claimed to have underestimated the costs of medical care for people suffering from smoking related diseases.[21] The overall net effect of smoking on

private (personal) and external costs has been studied also by Sloan et al[17] and Viscusi[18], who used US lifetable data to model the forth-coming lifelong net costs caused by smoking. As shown by van Baal et al., slightly different models can give markedly different results on the net effect of smoking, depending what assumptions are used[22]. In any case, sophisticated incidence-based datasets are ultimately required to establish the true health care costs incurred by smoking.[23] Because no results have been obtained from prospective, individual level data based on mortality, morbidity, pension and health care costs, the net economic impact of smoking on society has remained unclear. The aim of this study was to investigate this net economic effect by using data from a prospective 27-year follow-up of a cohort of 1,976 Finnish middle-aged men.

Methods

Study population

The subjects of the Kuopio Ischemic Heart Disease study (KIHD) were obtained from a randomly selected sample of 3,433 men, aged 42 to 60 years, who resided in the town of Kuopio or its surrounding rural communities. Of those invited, 2,682 (83 %) participated in the study. Of these, individuals from 54 to 60 years with complete data for smoking, income, healthcare costs, retirement, and mortality (n=1,976 men) were included in the final analyses. The baseline examinations were conducted between March 1984 and December 1989.[24] The mean follow-up time was 24.2 years (range 21.1±26.8 years). The KIHD study was approved by the Research Ethics Committee of the University of Kuopio, in Kuopio, Finland. Each participant gave written informed consent. The end of follow-up period was December 31, 2010.

A subject was defined as a smoker if he had ever smoked on a regular basis, and had smoked cigarettes, cigars, or a pipe within the past 30 days. The lifelong exposure to smoking ("cigarette pack-years") was estimated as the product of years smoked and the number of tobacco products smoked daily at the time of examination. "Years smoked" were defined as the sum of years of smoking regardless of when smoking had started, whether the subject had stopped smoking, or whether it had occurred continuously or during several periods. Data on mortality was obtained from Statistics Finland, and data on

healthcare costs from the Finnish Institute for Health and Welfare (THL). The health care costs did not include visits to general practitioners, home nursing, or medication and dental care costs in outpatient care, which have been estimated to be about 20–30% of total health care costs in this age group in Finland.[25] The amount of paid tobacco taxes was estimated on the basis of cigarette pack-years,[26] and the amount of paid income taxes was estimated by using the income tax rate of year 1987. The amount of occupational productivity and income taxes lost was calculated as the difference of age at retirement (relative to the retirement age of matched non-smokers) multiplied by the annual income and income tax of each smoker. “Income taxes paid” also included obligatory pension and healthcare insurance fees. All monetary values were expressed as Euros (€) and converted to the level of year 2009.

In the United Kingdom, the monetary value of one quality adjusted life year (QALY) has been estimated to be 20,000–30,000 Pounds for an individual having perfect health.[27] In the present study, we used a value of 30,000 Euros (about 25,100 Pounds in February 2012). In a recent large study on the effect of smoking on life expectancy, the quality-of-life score among former smokers with a BMI of 25–30, who were older than 65-years was estimated to be 0.71–0.77.[28] Therefore, we used a quality-of-life score of 0.74 for smokers in the present study, thus equalling to 0.74 x 30,000 Euros = 22,200 Euros for each life year lost due to smoking among former smokers aged over 65 years (deceased smokers who would be over 65 if they had lived).

Statistical analysis

Differences in baseline characteristics and costs were examined using the Student’s t-test. Descriptive data are presented as means and percentages. A p-value of less than 0.05 was considered statistically significant. These statistical analyses were performed using SPSS 17.0 for Windows. Life expectancy for those individuals still alive on 31st December 2009 was calculated by using life expectancy from the Life Table provided by Statistics Finland.[29]

Adjusted group difference in total cost was assessed also using bootstrap type analysis of covariance (ANCOVA) with adjustments for the propensity score. Potential variables for inclusion in the propensity score (age at baseline, BMI, systolic blood pressure, LDL-

cholesterol and years of education) were explored in logistic regression with a backward selection procedure (P<0.25 as selection criterion). Patients were stratified based on quintiles of the propensity score. Furthermore, the fit of the propensity score model was assessed by the Hosmer–Lemeshow test.

Results

The crude mortality rates were 351/493 (71.2%) among smokers, and 553/1483 (37.3%) among non-smokers, and the cause-specific mortality in each group is shown in Table 1. The observed age at death was 67.8 years for smokers, and 71.4 years for non-smokers. The predicted mean age at death was 72.1 for smokers and 80.7 years for non-smokers, indicating 8.6 years difference between two groups. When the effect of birth year on life expectancy was taken into account, the amount of life years lost due to smoking was 9.2 years. The demographic variables and smoking-related outcomes are shown in Table 2. Smokers had substantially lower mean BMI and educational level. Smokers also had a slightly lower mean systolic blood pressure and a slightly higher mean LDL cholesterol level. Smoking was associated with a moderate decrease in productive occupational career, income taxes paid, and hospital care costs, and showed a marked decrease in pension costs. The net effect of smoking on public finance was plus € 133,800 for these smokers during the follow-up when life years lost were not included, and minus € 70,200 when a monetary value for life years lost was included in the calculation. When propensity score method was applied, the result remained almost the same (€ 71.600, 95%CI € 52.300 to € 90.800).

Figure 1 demonstrates the average annual healthcare costs as a function of age among those individuals still alive, and Figure 2 shows the corresponding results when all individuals (also deceased) are included. The higher mortality results into lower annual costs among smokers after 72 years from birth.

Discussion

Hospital care costs were 1,600 Euros greater per person year for living individuals among the smokers during the follow-up, but due to a 8.6 year shorter life span, the total costs per

individual were 4,700 Euros lower among smokers than non-smokers during the entire study period. This study provides the first evidence for the net economic effect of smoking vs. non-smoking on costs related to health and social welfare, based on prospective, individual level data.

Smoking resulted in a moderate decrease in the productive occupational career and income taxes and pension fees paid, a moderate decrease in health care costs, and a marked decrease in the pension costs. The costs of smoking to society have been modelled by using estimates on increased mortality and morbidity.[6-18] However, none of these modelling studies investigated the overall net economic effect of smoking on public finance balance by using actual data from individuals, and only few had taken into account all of the following factors; lifetime productivity or income taxes and pension fees paid, pension costs, and a monetary value of life years lost.[17,18] Our results indicate that combined, these factors make considerable contribution to the overall net effect than merely health care costs which is in line with the modelling studies by Sloan et al.[17] and Viscosi[18]. If the potential increase in quality adjusted life years is taken into account, our results suggest that the life long net beneficial economic effect of early smoking cessation is more than € 70,000 per individual, and this sum did not change substantially when propensity score was applied in the analysis. Our results also indicate that reducing the rate of smoking has a huge beneficial economic effect on society, mainly due to increased life span and continued pension costs. In Finland, the National Institute for Health and Welfare aims to make Finland free of smoking by the year 2040. Since there are currently about 900,000 smokers in Finland, the average net effect of € 134,000 per individual on public finance balance (without taking into account the monetary value of life years lost) would correspond during the next decades to about 120 billion Euros total increase in costs (over 2.5-fold to annual state budget). However, this nominal deficit would be massively outweighed by about 2 years increase in life expectancy of the whole nation.

Our overall results on the net economic effect of smoking on public finance balance are contrary to the Philip Morris report. A major reason for this difference is that Little did not consider the inherent value of the quality adjusted life years lost. In other words, if we used an estimate of 0 Euros for each lost year of human life, then the positive economic effect of smoking in our study would have been even larger than the effect estimated by Little. However, when considering the implications of these results, the major question is whether

or not humans are to bevalued as commodities, like domesticated animals, or does human life maintain an inherent value even when the individual is not longer economically productive, as in retirement? In the field of health care, it is generally assumed that all human life – even that of the old and disabled – is precious and has value. This view is also currently accepted by national authorities throughout most of the modern world. Already in 1999, 387 billion USD was used in the U.S. for medical treatment and care of people older than 65 years.[30] Nowadays it is generally agreed that the monetary value of one additional life year of a healthy human being is about 20,000-30,000 British Pounds when additional costs of medical care are considered.[27] One may ask why societies continue to invest even larger amounts of money and other social resources to achieve a longer mean life span for citizens, while a more drastic increase could be achieved administratively, without any further costs, by substantially raising tobacco taxes and otherwise restricting access to smoking? There are two likely answers: either governmental authorities have not realized this fact, or they have realized it, but do not want to increase life expectancy due to a subsequent increase in both health care and pension costs.

While denying access to medical care for older people, in order to prevent a deficit in national economy, would not be possible because of common ethical concerns and public opinion, preventing a decrease in smoking rates essentially has the same effect, and is apparently more accepted by many societies. If this is the case, it would also explain the reluctance of governments to regulate the eating and other consumption habits of that negatively affect the general population by, for example, increasing the value added tax (VAT) on food products that are high in sugar and saturated fats, and decreasing VAT on fruits and vegetables, for example. The Czech prime minister stated in 2001 that smoking is beneficial for the state, because smokers die sooner.[17,18] Such comments have not been echoed by other state leaders since, however it is plausible that this view still influences tobacco policies in many modern countries. Therefore, governments should be transparent concerning which kind of knowledge their tobacco and food taxation policy is based on. Our study cannot answer the question on why cigarette taxes are still low in many countries. Therefore, this remains open and a topic for further research.

The strength of this study is based on empirical data that was gathered from a 27-year prospective study. Thus, no assumptions on healthcare, pension costs or discount

percentages of future costs were needed. One shortcoming is that this study did not include females, and it did not include visits to general practitioners, home nursing, or medication and dental care costs in outpatient care, which contribute to about 20–30% of the total health care costs among elderly and middle aged people in Finland.[25] In a previous 19-year follow-up study, it was observed that while the overall healthcare costs were higher among smokers aged 25–59 years, the costs of medication in outpatient care did not differ between smokers and non-smokers.[31] Thus it can be further estimated that the total health care costs might have been at the most about 6,000 to 7,000 Euros higher per individual among non-smokers when compared with smokers, instead of our modest estimate of about 5,000 Euros per individual. However, the magnitude of this difference (€ 1,000–2,000) is less than 2% of the pension costs, and does not have any substantial effect on these results. We also did not include the costs of fires or littering related to smoking, as this information was not available, yet the combined contribution of these factors is probably less than 1% of the total costs.[12] Since only 17% of the initiated subjects refused to participate, the generalisability of results can be considered quite sufficient.

It was presumed that smokers' lower education level and lower income level were not caused by smoking, and that differences in these characteristics were associated with smoking due to the fact that less educated individuals are more likely to start smoking than individuals with higher educational level. Therefore, it was assumed that smoking cessation would not substantially increase education level or income. It can be estimated that during a productive career of about 35 years, with an annual difference of € 2,970 in paid income taxes, smokers in our study have paid an average about 100,000 Euros less income taxes than non-smokers. If it were assumed that early smoking cessation would change these variables to the same levels as with non-smokers, the net difference between smokers vs. non-smokers would shift from € 134,000 to about € 30,000 in favour of smoking, if the value of life years lost are not included, and from € 70,000 to about € 170,000 in favour of non-smoking if the value of life years lost are included in the analysis. Either way, the principal conclusions on the net costs would remain the same. It is questionable if the tobacco taxes should be considered as beneficial increases in income to the state. For example, if an individual would not have been smoking, then he/she probably would have consumed more goods in the extra years of life and thus paid more taxes for those goods instead of the taxes paid for cigarettes. Overall, the estimate of a €

70,000 beneficial effect of early smoking cessation per individual is probably an underestimate.

Article summary

1) Article Focus

- No results have been obtained from prospective individual level data based on mortality, morbidity, pension and health care costs and, therefore, the net economic impact of smoking on society has remained unclear.

2) Key Messages

- Both the healthcare and pension costs are lower for smokers than non-smokers, the overall difference being more than 100,000 euros per individual.
- However, when a monetary value for life years lost was taken into account, the beneficial net effect of non-smoking to society was about €70,000 per individual.

3) Strengths and Limitations

- This study provides the first evidence for the net economic effect of smoking vs. non-smoking on costs related to health and social welfare, based on prospective data from individual subjects.
- Only males were included in study.

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Competing Interest: All authors have completed the Unified Competing Interest form at www.icmj.org.coi_disclosure.pdf (available on request from the corresponding author) and declare: Dr Tiihonen is a member of advisory board of AstraZeneca and Janssen-Cilag, and he reports serving as a consultant to Lundbeck, Organon, Janssen-Cilag, Eli Lilly, AstraZeneca, F. Hoffman-La Roche, and Bristol-Myers Squibb. He has received fees for giving expert opinions to Bristol-Myers Squibb and GlaxoSmithKline, and lecture fees from Janssen-Cilag, Bristol Myers-Squibb, Eli Lilly, Pfizer, Lundbeck, GlaxoSmithKline, Novartis, and Astra Zeneca. No further disclosures were reported.

Contributors: JT, KR and JK had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. JT wrote the first draft of the manuscript and all other authors read and had input in the final version of the paper. JT did study concept and design, KR and JK collected data, KR did statistical analysis and KR produced figures. JT is the guarantor.

Ethical approval: The KIHD study was approved by the Research Ethics Committee of the University of Kuopio, in Kuopio, Finland.

Data sharing: No additional data available.

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Figure legends

Figure 1. Average annual health care costs per living individual, in Euros, as a function of age.

Figure 2. Average annual health care costs among all individuals in Euros (including deceased persons).

Table 1. Cause-specific mortality among smokers and non-smokers.

Cause of death	Non-smokers (%)	Smokers (%)
Cardiovascular disease	267 (48%)	166 (47%)
Cancer (all)	146 (26%)	102 (29%)
Lung cancer	15 (3%)	47 (13%)
Respiratory disease	13 (2%)	20 (6%)
External causes of death	56 (10%)	28 (8%)
Other	71 (13%)	35 (10%)
Total	553 (100%)	351 (100%)

A total of 553 (37.3%) non-smokers and 351 (71.2%) smokers had died during the follow-up. Percentages indicate the proportions for cause of death from all deaths in each group. Cancer deaths include lung cancer deaths.

Table 2. Smoking-related outcomes.

	Non-smokers N=1483		Smokers N=493			
	Mean	S.D.	Mean	S.D.	Difference of means	p-value
Age at baseline, years	55.72	2.50	55.54	2.38	-0.2	0.17
Body mass index (BMI)	27.29	3.51	26.01	3.81	-1.3	< 0.001
Mean systolic blood pressure (mm Hg)	135.93	17.43	133.43	18.18	-2.5	0.007
LDL-cholesterol (mmol/l)	4.07	1.01	4.21	1.09	0.1	0.013
Years of education	8.19	3.32	7.52	2.74	-0.7	< 0.001
Age at death, years	80.71	8.40	72.13	8.89	-8.6	< 0.001
Life years lost due to smoking	0	0	9.19	8.15	9,2	< 0.001
Age at retirement, years	56.60	5.89	55.35	6.23	-1.3	< 0.001
Years of receiving pension	23.69	9.11	16.42	9.39	-7.3	< 0.001
Number of hospitalizations	10.74	12.34	10.84	10.89	0.1	0.88
Number of inpatient days	88.47	235.25	101.55	216.23	13.1	0.28
Years of smoking (at baseline)	2.69	8.96	31.81	9.72	29.1	< 0.001
Annual income, €	34,060	22,180	27,510	17.730	-6,550	< 0.001
Occupational productivity lost due to smoking, €	0	0	34,370	27,080	34,370	< 0.001
Income taxes lost due to smoking, €	0	0	11,660	12,550	11,660	< 0.001
Annual pension, €	20,440	13,330	16,180	9,730	-4,260	< 0.001
Reduced pension costs due to smoking,€	0	0	126,850	148,120	126,850	< 0.001
Reduced income taxes paid from pensions, €	0	0	34,230	48,650	34,230	< 0.001
Annual health care costs/living individuals, €	3,420	9,870	5,040	10,650	1,620	0.003
Total health care costs, €	79,290	173,420	74,570	154,950	-4,720	0.59
Tobacco tax paid, €	2,190	8,860	50,300	32,450	48,110	< 0.001
Life years lost due to smoking, €	0	0	203,960	180,890	203,960	<0.001
Total costs, life years lost not included, €	77,110	173,840	-56,680	195,130	-133,790	< 0.001
Total costs, life years lost included, €	77,110	173,840	147,280	195,960	70,170	<0.001

Total costs of smoking vs. non-smoking were calculated by taking into account the life-long difference (€/person) of health care costs (€ 4,720), tobacco taxes paid (€ 48,110), income taxes lost (€ 11,660), reduced pension costs (€ 126,850), and reduced taxes paid from pensions (€ 34,230). The smoking-related harms for the society were € 11,660 + € 34,230 = € 45,890, and the smoking-related benefits for the society were € 4,720 + € 48,110 + € 126,850 = € 179,680, and thus the net effect on public finance balance was € 133,790 positive for each smoking individual. When the value of 9.19 life years lost due to smoking (€ 203,960) was taken into account, the net effect became € 70,170 negative for each smoking individual. “Income taxes lost due to smoking” indicate the loss due to earlier disability/retirement, and “Pension costs” indicate the pensions paid by the state and pension companies. The value of one quality adjusted life year lost was estimated to be 0.74 x € 30,000 = € 22,200.[10,25]

Figure 1. Average annual health care costs per living individual, in Euros, as a function of age.

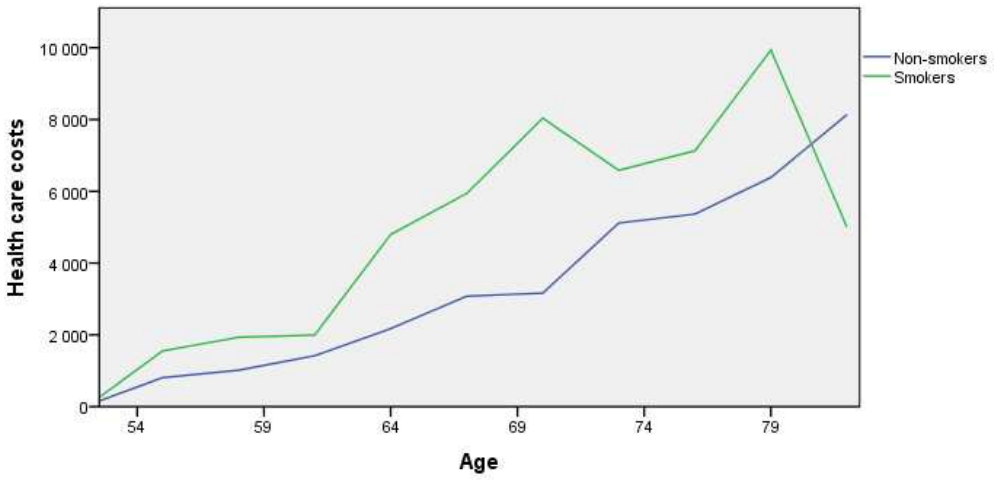
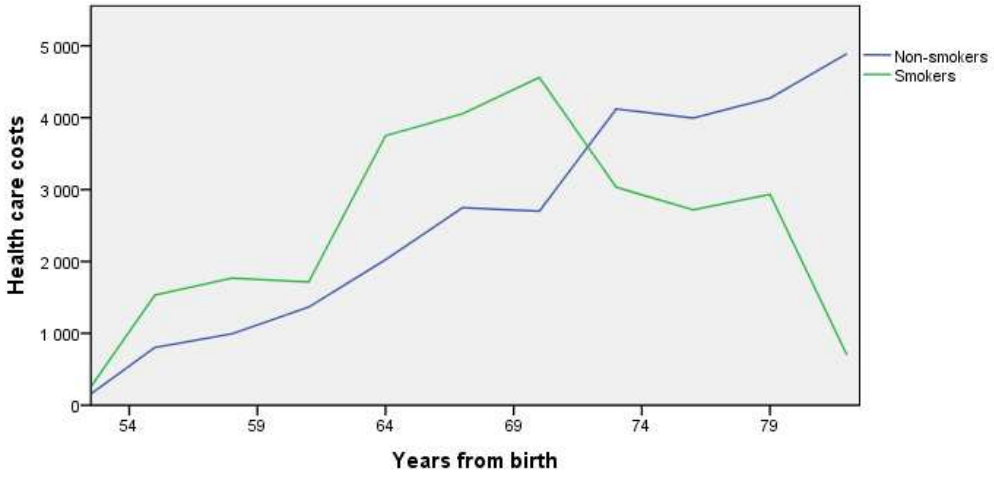


Figure 2. Average annual health care costs among all individuals in Euros (including deceased persons).



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Smoking and Healthcare and Welfare Costs. A Cohort Study.

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Abstract

Objective: To study the net economic effect of smoking on society.

Design, Setting, and Patients: We studied mortality, paid income and tobacco taxes, and the cumulative costs due to pensions and medical care among both tobacco smoking and non-smoking individuals in a 27-year prospective cohort study of 1,976 men from Eastern Finland. These individuals were 54–60 years old at the beginning of the follow-up.

Main Outcome Measures: The net contribution of smoking vs. non-smoking individuals to public finance balance (euros).

Results: Smoking was associated with a greater mean annual health care cost of €1,600 per living individual during follow-up. However, due to a shorter life span of 8.6 years, smokers' mean total healthcare costs during the entire study period were actually €4,700 lower than for non-smokers. For the same reason, each smoker missed 7.3 years (€126,850) of pension. Overall, smokers' average net contribution to the public finance balance was €133,800 greater per individual compared with non-smokers. However, if each lost quality adjusted life year is considered to be worth €22,200, the net effect is reversed to be €70,200 (€ 71.600 when adjusted with propensity score) per individual in favour of non-smoking.

Conclusion: Smoking was associated with a moderate decrease in health care costs, and a marked decrease in pension costs due to increased mortality. However, when a monetary value for life years lost was taken into account, the beneficial net effect of non-smoking to society was about €70,000 per individual.

Introduction

Smoking is the single most important preventable cause of premature death in industrialized countries[1], and tobacco taxation is still the most cost-effective method for decreasing the prevalence of smoking. Increases in tobacco taxes have encouraged 9 to 17% of smokers to quite[2,3], and in the long run the main effect of taxation is a reduction in the incidence of new young smokers.[4] Early smoking cessation increases lifespan by about 9-10 years,[5] and if the smoking rate diminished by 10 percentage points, life expectancy would increase by about one year. It has been estimated that a 10% increase in the price of smoked tobacco will result in about a 5% decrease in cigarette consumption,[4] yet tobacco taxes are still low in many countries. Thus, it would be interesting to know why so many governments in the world continue to increase spending on health care costs, while a substantial savings and advances in life expectancy are readably available by administratively increasing tobacco taxes? There are two plausible explanations: the governments do not know about the correlation between increasing tobacco taxes on increasing life expectancy, or they realize this effect, but do not want to increase the life expectancy.

The net effect of smoking on healthcare costs has been investigated in several studies.[6-18] Some modelling studies have suggested that while smokers suffer more from many kinds of diseases, non-smokers incur more healthcare costs because they live longer,[6,7,8,11,12] yet others have reached the opposite conclusion.[9,10,13-18] Only ~~two~~few of these studies have included both pension and insurance costs,[7,12,17,18] and ~~only one study has included~~ paid tobacco taxes.[12,17,18] In 2001, Philip Morris provided a report to the Government of the Czech Republic, which indicated that the effect of smoking on the public finance balance in the Czech Republic in 1999 was positive and estimated to be 5,815 million korunas (about 150 million USD).[12] Although this report generated outraged reactions worldwide, Milos Zeman, the Czech prime minister stated “As a smoker, I support the state budget, because in the Czech Republic, we pay tax on tobacco. Also, smokers die sooner, and the state does not need to look after them in their old age”. [19,20] ~~To our knowledge, the Philip Morris report is the only published study thus far on the overall effect of smoking on the balance of public finance.~~ This report was based on many assumptions that were obtained through theoretical modelling, and it did not give any monetary value for life years lost because of

smoking, and it was claimed to have underestimated the costs of medical care for people suffering from smoking related diseases.[21] The overall net effect of smoking on private (personal) and external costs has been studied also by Sloan et al[17] and Viscusi[18], who used US lifetable data to model the forth-coming lifelong net costs caused by smoking. As shown by van Baal et al., slightly different models can give markedly different results on the net effect of smoking, depending what assumptions are used[22]. In any case, sophisticated incidence-based datasets are ultimately required to establish the true health care costs incurred by smoking.[23] Because no results have been obtained from ~~empirical~~prospective, individual level data based on mortality, morbidity, pension and health care costs, the net economic impact of smoking on society has remained unclear. The aim of this study was to investigate this net economic effect by using data from a prospective 27-year follow-up of a cohort of 1,976 Finnish middle-aged men.

Comment [r1]: Reviewer 1

Methods

Study population

The subjects of the Kuopio Ischemic Heart Disease study (KIHD) were obtained from a randomly selected sample of 3,433 men, aged 42 to 60 years, who resided in the town of Kuopio or its surrounding rural communities. Of those invited, 2,682 (83 %) participated in the study. Of these, individuals from 54 to 60 years with complete data for smoking, income, healthcare costs, retirement, and mortality (n=1,976 men) were included in the final analyses. The baseline examinations were conducted between March 1984 and December 1989.[24] The mean follow-up time was 24.2 years (range 21.1±26.8 years). The KIHD study was approved by the Research Ethics Committee of the University of Kuopio, in Kuopio, Finland. Each participant gave written informed consent. The end of follow-up period was December 31, 2010.

A subject was defined as a smoker if he had ever smoked on a regular basis, and had smoked cigarettes, cigars, or a pipe within the past 30 days. The lifelong exposure to smoking ("cigarette pack-years") was estimated as the product of years smoked and the number of tobacco products smoked daily at the time of examination. "Years smoked" were defined as the sum of years of smoking regardless of when smoking had started,

whether the subject had stopped smoking, or whether it had occurred continuously or during several periods. Data on mortality was obtained from Statistics Finland, and data on healthcare costs from the Finnish Institute for Health and Welfare (THL). The health care costs did not include visits to general practitioners, home nursing, or medication and dental care costs in outpatient care, which have been estimated to be about 20–30% of total health care costs in this age group in Finland.[25] The amount of paid tobacco taxes was estimated on the basis of cigarette pack-years,[26] and the amount of paid income taxes was estimated by using the income tax rate of year 1987. The amount of occupational productivity and income taxes lost was calculated as the difference of age at retirement (relative to the retirement age of matched non-smokers) multiplied by the annual income and income tax of each smoker. "Income taxes paid" also included obligatory pension and healthcare insurance fees. All monetary values were expressed as Euros (€) and converted to the level of year 2009.

In the United Kingdom, the monetary value of one quality adjusted life year (QALY) has been estimated to be 20,000–30,000 Pounds for an individual having perfect health.[27] In the present study, we used a value of 30,000 Euros (about 25,100 Pounds in February 2012). In a recent large study on the effect of smoking on life expectancy, the quality-of-life score among former smokers with a BMI of 25–30, who were older than 65-years was estimated to be 0.71–0.77.[28] Therefore, we used a quality-of-life score of 0.74 for smokers in the present study, thus equalling to 0.74 x 30,000 Euros = 22,200 Euros for each life year lost due to smoking among former smokers aged over 65 years (deceased smokers who would be over 65 if they had lived).

Statistical analysis

Differences in baseline characteristics and costs were examined using the Student's t-test. Descriptive data are presented as means and percentages. A p-value of less than 0.05 was considered statistically significant. These statistical analyses were performed using SPSS 17.0 for Windows. Life expectancy for those individuals still alive on 31st December 2009 was calculated by using life expectancy from the Life Table provided by Statistics Finland.[29]

Adjusted group difference in total cost was assessed also using bootstrap type analysis of covariance (ANCOVA) with adjustments for the propensity score. Potential variables for inclusion in the propensity score (age at baseline, BMI, systolic blood pressure, LDL-cholesterol and years of education) were explored in logistic regression with a backward selection procedure (P<0.25 as selection criterion). Patients were stratified based on quintiles of the propensity score. Furthermore, the fit of the propensity score model was assessed by the Hosmer–Lemeshow test.

Comment [r2]: Reviewer 1

Results

The crude mortality rates were 351/493 (71.2%) among smokers, and 553/1483 (37.3%) among non-smokers, and the cause-specific mortality in each group is shown in Table 1. The observed age at death was 67.8 years for smokers, and 71.4 years for non-smokers. The predicted mean age at death was 72.1 for smokers and 80.7 years for non-smokers, indicating 8.6 years difference between two groups. When the effect of birth year on life expectancy was taken into account, the amount of life years lost due to smoking was 9.2 years. The demographic variables and smoking-related outcomes are shown in Table 2. Smokers had substantially lower mean BMI and educational level. Smokers also had a slightly lower mean systolic blood pressure and a slightly higher mean LDL cholesterol level. Smoking was associated with a moderate decrease in productive occupational career, income taxes paid, and hospital care costs, and showed a marked decrease in pension costs. The net effect of smoking on public finance was plus € 133,800 for these smokers during the follow-up when life years lost were not included, and minus € 70,200 when a monetary value for life years lost was included in the calculation. When propensity score method was applied, the result remained almost the same (€ 71.600, 95%CI € 52.300 to € 90.800).

Comment [r3]: Reviewer 1

Figure 1 demonstrates the average annual healthcare costs as a function of age among those individuals still alive, and Figure 2 shows the corresponding results when all individuals (also deceased) are included. The higher mortality results into lower annual costs among smokers after 72 years from birth.

Discussion

Hospital care costs were 1,600 Euros greater per person year for living individuals among the smokers during the follow-up, but due to a 8.6 year shorter life span, the total costs per individual were 4,700 Euros lower among smokers than non-smokers during the entire study period. This study provides the first evidence for the net economic effect of smoking vs. non-smoking on costs related to health and social welfare, based on prospective, individual level data.

Smoking resulted in a moderate decrease in the productive occupational career and income taxes and pension fees paid, a moderate decrease in health care costs, and a marked decrease in the pension costs. The costs of smoking to society have been modelled by using estimates on increased mortality and morbidity.[6-18] However, none of these modelling studies investigated the overall net economic effect of smoking on public finance balance by using actual data from individuals, and only few had takenor by taking into account all of the following factors; lifetime productivity or income taxes and pension fees paid, pension costs, and a monetary value of life years lost.[17,18] Our results indicate that combined, these factors make considerable contribution to the overall net effect than merely health care costs which is in line with the modelling studies by Sloan et al.[17] and Viscosi[18]. If the potential increase in quality adjusted life years is taken into account, our results suggest that the life long net beneficial economic effect of early smoking cessation is more than € 70,000 per individual, and this sum did not change substantially when propensity score was applied in the analysis. Our results also indicate that reducing the rate of smoking has a huge beneficial economic effect on society, mainly due to increased life span and continued pension costs. In Finland, the National Institute for Health and Welfare aims to make Finland free of smoking by the year 2040. Since there are currently about 900,000 smokers in Finland, the average net effect of € 134,000 per individual on public finance balance (without taking into account the monetary value of life years lost) would correspond during the next decades to about 120 billion Euros total increase in costs (over 2.5-fold to annual state budget). However, this nominal deficit would be massively outweighed by about 2 years increase in life expectancy of the whole nation.

Our overall results on the net economic effect of smoking on public finance balance are contrary to the Philip Morris report. A major reason for this difference is that Little did not consider the inherent value of the quality adjusted life years lost. In other words, if we used

Comment [r4]: Reviewer 1

Comment [r5]: Reviewer 1

an estimate of 0 Euros for each lost year of human life, then the positive economic effect of smoking in our study would have been even larger than the effect estimated by Little. However, when considering the implications of these results, the major question is whether or not humans are to bevalued as commodities, like domesticated animals, or does human life maintain an inherent value even when the individual is not longer economically productive, as in retirement? In the field of health care, it is generally assumed that all human life – even that of the old and disabled – is precious and has value. This view is also currently accepted by national authorities throughout most of the modern world. Already in 1999, 387 billion USD was used in the U.S. for medical treatment and care of people older than 65 years.[30] Nowadays it is generally agreed that the monetary value of one additional life year of a healthy human being is about 20,000-30,000 British Pounds when additional costs of medical care are considered.[27] One may ask why societies continue to invest even larger amounts of money and other social resources to achieve a longer mean life span for citizens, while a more drastic increase could be achieved administratively, without any further costs, by substantially raising tobacco taxes and otherwise restricting access to smoking? There are two likely answers: either governmental authorities have not realized this fact, or they have realized it, but do not want to increase life expectancy due to a subsequent increase in both health care and pension costs.

While denying access to medical care for older people, in order to prevent a deficit in national economy, would not be possible because of common ethical concerns and public opinion, preventing a decrease in smoking rates essentially has the same effect, and is apparently more accepted by many societies. If this is the case, it would also explain the reluctance of governments to regulate the eating and other consumption habits of that negatively affect the general population by, for example, increasing the value added tax (VAT) on food products that are high in sugar and saturated fats, and decreasing VAT on fruits and vegetables, for example. The Czech prime minister stated in 2001 that smoking is beneficial for the state, because smokers die sooner.[17,18] Such comments have not been echoed by other state leaders since, however it is plausible that this view still influences tobacco policies in many modern countries. Therefore, governments should be transparent concerning which kind of knowledge their tobacco and food taxation policy is based on. Our study cannot answer the question on why cigarette taxes are still low in many countries. Therefore, this remains open and a topic for further research.

Comment [r6]: Reviewer 2

The strength of this study is based on empirical data that was gathered from a 27-year prospective study. Thus, no assumptions on healthcare, pension costs or discount percentages of future costs were needed. One shortcoming is that this study did not include females, and it did not include visits to general practitioners, home nursing, or medication and dental care costs in outpatient care, which contribute to about 20–30% of the total health care costs among elderly and middle aged people in Finland.[25] In a previous 19-year follow-up study, it was observed that while the overall healthcare costs were higher among smokers aged 25–59 years, the costs of medication in outpatient care did not differ between smokers and non-smokers.[31] Thus it can be further estimated that the total health care costs might have been at the most about 6,000 to 7,000 Euros higher per individual among non-smokers when compared with smokers, instead of our modest estimate of about 5,000 Euros per individual. However, the magnitude of this difference (€ 1,000–2,000) is less than 2% of the pension costs, and does not have any substantial effect on these results. We also did not include the costs of fires or littering related to smoking, as this information was not available, yet the combined contribution of these factors is probably less than 1% of the total costs.[12] Since only 17% of the initiated subjects refused to participate, the generalisability of results can be considered quite sufficient.

It was presumed that smokers' lower education level and lower income level were not caused by smoking, and that differences in these characteristics were associated with smoking due to the fact that less educated individuals are more likely to start smoking than individuals with higher educational level. Therefore, it was assumed that smoking cessation would not substantially increase education level or income. It can be estimated that during a productive career of about 35 years, with an annual difference of € 2,970 in paid income taxes, smokers in our study have paid an average about 100,000 Euros less income taxes than non-smokers. If it were assumed that early smoking cessation would change these variables to the same levels as with non-smokers, the net difference between smokers vs. non-smokers would shift from € 134,000 to about € 30,000 in favour of smoking, if the value of life years lost are not included, and from € 70,000 to about € 170,000 in favour of non-smoking if the value of life years lost are included in the analysis. Either way, the principal conclusions on the net costs would remain the same. It is questionable if the tobacco taxes should be considered as beneficial increases in income

to the state. For example, if an individual would not have been smoking, then he/she probably would have consumed more goods in the extra years of life and thus paid more taxes for those goods instead of the taxes paid for cigarettes. Overall, the estimate of a € 70,000 beneficial effect of early smoking cessation per individual is probably an underestimate.

Article summary

1) Article Focus

- No results have been obtained from prospective individual level data based on mortality, morbidity, pension and health care costs and, therefore, the net economic impact of smoking on society has remained unclear.

2) Key Messages

- Both the healthcare and pension costs are lower for smokers than non-smokers, the overall difference being more than 100,000 euros per individual.
- However, when a monetary value for life years lost was taken into account, the beneficial net effect of non-smoking to society was about €70,000 per individual.

3) Strengths and Limitations

- This study provides the first evidence for the net economic effect of smoking vs. non-smoking on costs related to health and social welfare, based on prospective data from individual subjects.
- Only males were included in study.

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Competing Interest: All authors have completed the Unified Competing Interest form at www.icmj.org.coi_disclosure.pdf (available on request from the corresponding author) and declare: Dr Tiihonen is a member of advisory board of AstraZeneca and Janssen-Cilag, and he reports serving as a consultant to Lundbeck, Organon, Janssen-Cilag, Eli Lilly, AstraZeneca, F. Hoffman-La Roche, and Bristol-Myers Squibb. He has received fees for giving expert opinions to Bristol-Myers Squibb and GlaxoSmithKline, and lecture fees from Janssen-Cilag, Bristol Myers-Squibb, Eli Lilly, Pfizer, Lundbeck, GlaxoSmithKline, Novartis, and Astra Zeneca. No further disclosures were reported.

Contributors: JT, KR and JK had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. JT wrote the first draft of the manuscript and all other authors read and had input in the final version of the paper. JT did study concept and design, KR and JK collected data, KR did statistical analysis and KR produced figures. JT is the guarantor.

Ethical approval: The KIHD study was approved by the Research Ethics Committee of the University of Kuopio, in Kuopio, Finland.

Data sharing: No additional data available.

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Figure legends

Figure 1. Average annual health care costs per living individual, in Euros, as a function of age.

Figure 2. Average annual health care costs among all individuals in Euros (including deceased persons).

Table 1. Cause-specific mortality among smokers and non-smokers.

Cause of death	Non-smokers (%)	Smokers (%)
Cardiovascular disease	267 (48%)	166 (47%)
Cancer (all)	146 (26%)	102 (29%)
Lung cancer	15 (3%)	47 (13%)
Respiratory disease	13 (2%)	20 (6%)
External causes of death	56 (10%)	28 (8%)
Other	71 (13%)	35 (10%)
Total	553 (100%)	351 (100%)

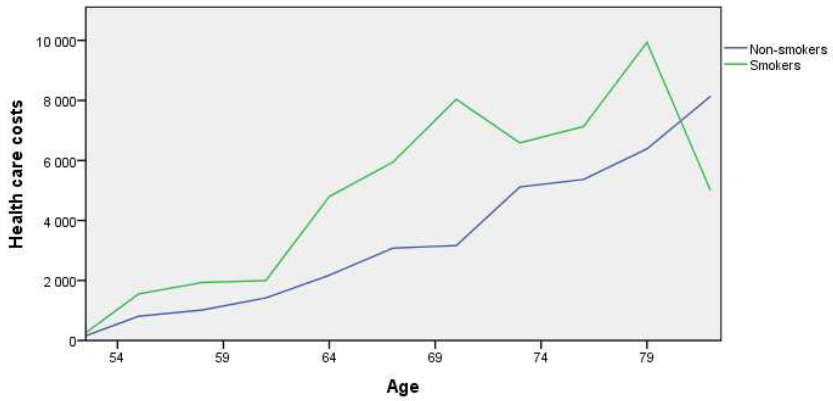
A total of 553 (37.3%) non-smokers and 351 (71.2%) smokers had died during the follow-up. Percentages indicate the proportions for cause of death from all deaths in each group. Cancer deaths include lung cancer deaths.

Table 2. Smoking-related outcomes.

	Non-smokers N=1483		Smokers N=493			
	Mean	S.D.	Mean	S.D.	Difference of means	p-value
Age at baseline, years	55.72	2.50	55.54	2.38	-0.2	0.17
Body mass index (BMI)	27.29	3.51	26.01	3.81	-1.3	< 0.001
Mean systolic blood pressure (mm Hg)	135.93	17.43	133.43	18.18	-2.5	0.007
LDL-cholesterol (mmol/l)	4.07	1.01	4.21	1.09	0.1	0.013
Years of education	8.19	3.32	7.52	2.74	-0.7	< 0.001
Age at death, years	80.71	8.40	72.13	8.89	-8.6	< 0.001
Life years lost due to smoking	0	0	9.19	8.15	9,2	< 0.001
Age at retirement, years	56.60	5.89	55.35	6.23	-1.3	< 0.001
Years of receiving pension	23.69	9.11	16.42	9.39	-7.3	< 0.001
Number of hospitalizations	10.74	12.34	10.84	10.89	0.1	0.88
Number of inpatient days	88.47	235.25	101.55	216.23	13.1	0.28
Years of smoking (at baseline)	2.69	8.96	31.81	9.72	29.1	< 0.001
Annual income, €	34,060	22,180	27,510	17.730	-6,550	< 0.001
Occupational productivity lost due to smoking, €	0	0	34,370	27,080	34,370	< 0.001
Income taxes lost due to smoking, €	0	0	11,660	12,550	11,660	< 0.001
Annual pension, €	20,440	13,330	16,180	9,730	-4,260	< 0.001
Reduced pension costs due to smoking,€	0	0	126,850	148,120	126,850	< 0.001
Reduced income taxes paid from pensions, €	0	0	34,230	48,650	34,230	< 0.001
Annual health care costs/living individuals, €	3,420	9,870	5,040	10,650	1,620	0.003
Total health care costs, €	79,290	173,420	74,570	154,950	-4,720	0.59
Tobacco tax paid, €	2,190	8,860	50,300	32,450	48,110	< 0.001
Life years lost due to smoking, €	0	0	203,960	180,890	203,960	<0.001
Total costs, life years lost not included, €	77,110	173,840	-56,680	195,130	-133,790	< 0.001
Total costs, life years lost included, €	77,110	173,840	147,280	195,960	70,170	<0.001

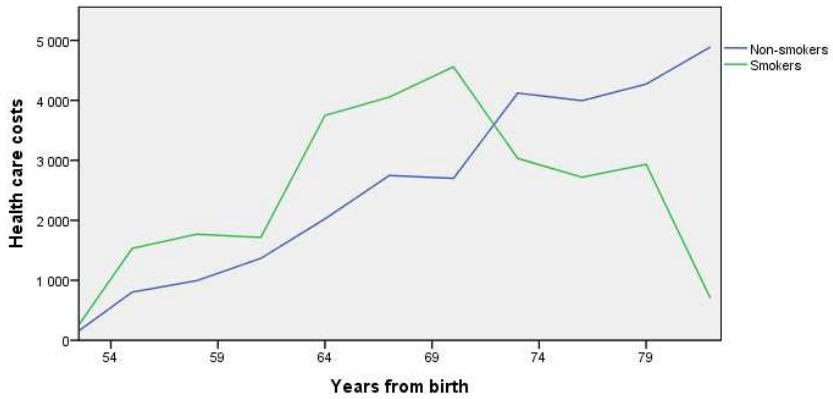
Total costs of smoking vs. non-smoking were calculated by taking into account the life-long difference (€/person) of health care costs (€ 4,720), tobacco taxes paid (€ 48,110), income taxes lost (€ 11,660), reduced pension costs (€ 126,850), and reduced taxes paid from pensions (€ 34,230). The smoking-related harms for the society were € 11,660 + € 34,230 = € 45,890, and the smoking-related benefits for the society were € 4,720 + € 48,110 + € 126,850 = € 179,680, and thus the net effect on public finance balance was € 133,790 positive for each smoking individual. When the value of 9.19 life years lost due to smoking (€ 203,960) was taken into account, the net effect became € 70,170 negative for each smoking individual. “Income taxes lost due to smoking” indicate the loss due to earlier disability/retirement, and “Pension costs” indicate the pensions paid by the state and pension companies. The value of one quality adjusted life year lost was estimated to be 0.74 x € 30,000 = € 22,200.[10,25]

Figure 1. Average annual health care costs per living individual, in Euros, as a function of age.



20

Figure 2. Average annual health care costs among all individuals in Euros (including deceased persons).



STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1 Done	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2 pp. 3,4	Explain the scientific background and rationale for the investigation being reported
Objectives	3 p. 4	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4 p. 4	Present key elements of study design early in the paper
Setting	5 p. 4	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 pp. 4,5	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7 pp. 4,5	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8* pp.4,5	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 Not done	Describe any efforts to address potential sources of bias
Study size	10 p. 4	Explain how the study size was arrived at
Quantitative variables	11 pp. 4,5	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 p. 5	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed No missing data
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13* p. 4	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage No drop-outs or missing data
		(c) Consider use of a flow diagram
Descriptive data	14* Done	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Table 2
		(b) Indicate number of participants with missing data for each variable of interest No missing data
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount) p. 4
Outcome data	15* Done	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures Tables 1 and 2
Main results	16 Done	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses No such analyses
Discussion		
Key results	18 pp. 6, 7	Summarise key results with reference to study objectives
Limitations	19 pp. 8, 9	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20 p. 9	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21 p. 9	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22 p. 11	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

The Net Effect of Smoking on Healthcare and Welfare Costs. A Cohort Study.

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The Net Effect of Smoking on Healthcare and Welfare Costs. A Cohort Study.

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Keywords: smoking; healthcare; costs; mortality

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Abstract

Objective: To study the net economic effect of smoking on society.

Design: Prospective Cohort Study

Setting: Eastern Finland

Patients: We studied mortality, paid income and tobacco taxes, and the cumulative costs due to pensions and medical care among both tobacco smoking and non-smoking individuals in a 27-year prospective cohort study of 1,976 men from Eastern Finland. These individuals were 54–60 years old at the beginning of the follow-up.

Main Outcome Measures: The net contribution of smoking vs. non-smoking individuals to public finance balance (euros).

Results: Smoking was associated with a greater mean annual health care cost of €1,600 per living individual during follow-up. However, due to a shorter life span of 8.6 years, smokers' mean total healthcare costs during the entire study period were actually €4,700 lower than for non-smokers. For the same reason, each smoker missed 7.3 years (€126,850) of pension. Overall, smokers' average net contribution to the public finance balance was €133,800 greater per individual compared with non-smokers. However, if each lost quality adjusted life year is considered to be worth €22,200, the net effect is reversed to be €70,200 (€ 71.600 when adjusted with propensity score) per individual in favour of non-smoking.

Conclusion: Smoking was associated with a moderate decrease in health care costs, and a marked decrease in pension costs due to increased mortality. However, when a monetary value for life years lost was taken into account, the beneficial net effect of non-smoking to society was about €70,000 per individual.

Introduction

Smoking is the single most important preventable cause of premature death in industrialized countries[1], and tobacco taxation is still the most cost-effective method for decreasing the prevalence of smoking. Increases in tobacco taxes have encouraged 9 to 17% of smokers to quite[2,3], and in the long run the main effect of taxation is a reduction in the incidence of new young smokers.[4] Early smoking cessation increases lifespan by about 9-10 years,[5] and if the smoking rate diminished by 10 percentage points, life expectancy would increase by about one year. It has been estimated that a 10% increase in the price of smoked tobacco will result in about a 5% decrease in cigarette consumption,[4] yet tobacco taxes are still low in many countries. Thus, it would be interesting to know why so many governments in the world continue to increase spending on health care costs, while a substantial savings and advances in life expectancy are readably available by administratively increasing tobacco taxes? There are two plausible explanations: the governments do not know about the correlation between increasing tobacco taxes on increasing life expectancy, or they realize this effect, but do not want to increase the life expectancy. One possible explanation is that governments are reacting to pressure from cigarette companies and smokers (either implicit or explicit) which prevents tax increases.

The net effect of smoking on healthcare costs has been investigated in several studies.[6-18] Some modelling studies have suggested that while smokers suffer more from many kinds of diseases, non-smokers incur more healthcare costs because they live longer,[6,7,8,11,12] yet others have reached the opposite conclusion.[9,10,13-18] Only few of these studies have included both pension and insurance costs,[7,12,17,18] and paid tobacco taxes.[12,17,18] In 2001, Philip Morris provided a report to the Government of the Czech Republic, which indicated that the effect of smoking on the public finance balance in the Czech Republic in 1999 was positive and estimated to be 5,815 million korunas (about 150 million USD).[12] Although this report generated outraged reactions worldwide, Milos Zeman, the Czech prime minister stated “As a smoker, I support the state budget, because in the Czech Republic, we pay tax on tobacco. Also, smokers die sooner, and the state does not need to look after them in their old age”. [19,20] This report was based on many assumptions that were obtained through theoretical modelling, and it did not give any monetary value for life years lost

because of smoking, and it was claimed to have underestimated the costs of medical care for people suffering from smoking related diseases.[21] The overall net effect of smoking on private (personal) and external costs has been studied also by Sloan et al[17] and Viscusi[18], who used US lifetable data to model the forth-coming lifelong net costs caused by smoking. As shown by van Baal et al., slightly different models can give markedly different results on the net effect of smoking, depending what assumptions are used[22]. In any case, sophisticated incidence-based datasets are ultimately required to establish the true health care costs incurred by smoking.[23] Because no results have been obtained from prospective, individual level data based on mortality, morbidity, pension and health care costs, the net economic impact of smoking on society has remained unclear. The aim of this study was to investigate this net economic effect by using data from a prospective 27-year follow-up of a cohort of 1,976 Finnish middle-aged men.

Methods

Study population

The subjects of the Kuopio Ischemic Heart Disease study (KIHD) were obtained from a randomly selected sample of 3,433 men, aged 42 to 60 years, who resided in the town of Kuopio or its surrounding rural communities. Of those invited, 2,682 (83 %) participated in the study. Of these, individuals from 54 to 60 years with complete data for smoking, income, healthcare costs, retirement, and mortality (n=1,976 men) were included in the final analyses. The baseline examinations were conducted between March 1984 and December 1989.[24] The mean follow-up time was 24.2 years (range 21.1±26.8 years). The KIHD study was approved by the Research Ethics Committee of the University of Kuopio, in Kuopio, Finland. Each participant gave written informed consent. The end of follow-up period was December 31, 2010.

A subject was defined as a smoker if he had ever smoked on a regular basis, and had smoked cigarettes, cigars, or a pipe within the past 30 days. The lifelong exposure to smoking ("cigarette pack-years") was estimated as the product of years smoked and the number of tobacco products smoked daily at the time of examination. "Years smoked" were defined as the sum of years of smoking regardless of when smoking had started,

whether the subject had stopped smoking, or whether it had occurred continuously or during several periods. Data on mortality was obtained from Statistics Finland, and data on healthcare costs from the Finnish Institute for Health and Welfare (THL). The health care costs did not include visits to general practitioners, home nursing, or medication and dental care costs in outpatient care, which have been estimated to be about 20–30% of total health care costs in this age group in Finland.[25] The amount of paid tobacco taxes was estimated on the basis of cigarette pack-years,[26] and the amount of paid income taxes was estimated by using the income tax rate of year 1987. The amount of occupational productivity and income taxes lost was calculated as the difference of age at retirement (relative to the retirement age of matched non-smokers) multiplied by the annual income and income tax of each smoker. “Income taxes paid” also included obligatory pension and healthcare insurance fees. All monetary values were expressed as Euros (€) and converted to the level of year 2009.

In the United Kingdom, the monetary value of one quality adjusted life year (QALY) has been estimated to be 20,000–30,000 Pounds for an individual having perfect health.[27] In the present study, we used a value of 30,000 Euros (about 25,100 Pounds in February 2012). In a recent large study on the effect of smoking on life expectancy, the quality-of-life score among former smokers with a BMI of 25–30, who were older than 65-years was estimated to be 0.71–0.77.[28] Therefore, we used a quality-of-life score of 0.74 for smokers in the present study, thus equalling to 0.74 x 30,000 Euros = 22,200 Euros for each life year lost due to smoking among former smokers aged over 65 years (deceased smokers who would be over 65 if they had lived).

Statistical analysis

Differences in baseline characteristics and costs were examined using the Student’s t-test. Descriptive data are presented as means and percentages. A p-value of less than 0.05 was considered statistically significant. These statistical analyses were performed using SPSS 17.0 for Windows. Life expectancy for those individuals still alive on 31st December 2009 was calculated by using life expectancy from the Life Table provided by Statistics Finland.[29]

Adjusted group difference in total cost was assessed also using bootstrap type analysis of covariance (ANCOVA) with adjustments for the propensity score. Potential variables for inclusion in the propensity score (age at baseline, BMI, systolic blood pressure, LDL-cholesterol and years of education) were explored in logistic regression with a backward selection procedure (P<0.25 as selection criterion). Patients were stratified based on quintiles of the propensity score. Furthermore, the fit of the propensity score model was assessed by the Hosmer–Lemeshow test.

Results

The crude mortality rates were 351/493 (71.2%) among smokers, and 553/1483 (37.3%) among non-smokers, and the cause-specific mortality in each group is shown in Table 1. The observed age at death was 67.8 years for smokers, and 71.4 years for non-smokers. The predicted mean age at death was 72.1 for smokers and 80.7 years for non-smokers, indicating 8.6 years difference between two groups. When the effect of birth year on life expectancy was taken into account, the amount of life years lost due to smoking was 9.2 years. The demographic variables and smoking-related outcomes are shown in Table 2. Smokers had substantially lower mean BMI and educational level. Smokers also had a slightly lower mean systolic blood pressure and a slightly higher mean LDL cholesterol level. Smoking was associated with a moderate decrease in productive occupational career, income taxes paid, and hospital care costs, and showed a marked decrease in pension costs. The net effect of smoking on public finance was plus € 133,800 for these smokers during the follow-up when life years lost were not included, and minus € 70,200 when a monetary value for life years lost was included in the calculation. When propensity score method was applied, the result remained almost the same (€ 71.600, 95%CI € 52.300 to € 90.800).

Figure 1 demonstrates the average annual healthcare costs as a function of age among those individuals still alive, and Figure 2 shows the corresponding results when all individuals (also deceased) are included. The higher mortality results into lower annual costs among smokers after 72 years from birth.

Discussion

Hospital care costs were 1,600 Euros greater per person year for living individuals among the smokers during the follow-up, but due to a 8.6 year shorter life span, the total costs per individual were 4,700 Euros lower among smokers than non-smokers during the entire study period. This study provides the first evidence for the net economic effect of smoking vs. non-smoking on costs related to health and social welfare, based on prospective, individual level data.

Smoking resulted in a moderate decrease in the productive occupational career and income taxes and pension fees paid, a moderate decrease in health care costs, and a marked decrease in the pension costs. The costs of smoking to society have been modelled by using estimates on increased mortality and morbidity.[6-18] However, none of these modelling studies investigated the overall net economic effect of smoking on public finance balance by using actual data from individuals, and only few had taken into account all of the following factors; lifetime productivity or income taxes and pension fees paid, pension costs, and a monetary value of life years lost.[17,18] Our results indicate that combined, these factors make considerable contribution to the overall net effect than merely health care costs which is in line with the modelling studies by Sloan et al.[17] and Viscosi[18]. If the potential increase in quality adjusted life years is taken into account, our results suggest that the life long net beneficial economic effect of early smoking cessation is more than € 70,000 per individual, and this sum did not change substantially when propensity score was applied in the analysis. Our results also indicate that reducing the rate of smoking has a huge beneficial economic effect on society, mainly due to increased life span and continued pension costs. In Finland, the National Institute for Health and Welfare aims to make Finland free of smoking by the year 2040. Since there are currently about 900,000 smokers in Finland, the average net effect of € 134,000 per individual on public finance balance (without taking into account the monetary value of life years lost) would correspond during the next decades to about 120 billion Euros total increase in costs (over 2.5-fold to annual state budget). However, this nominal deficit would be massively outweighed by about 2 years increase in life expectancy of the whole nation.

Our overall results on the net economic effect of smoking on public finance balance are contrary to the Philip Morris report. A major reason for this difference is that Little did not

consider the inherent value of the quality adjusted life years lost. In other words, if we used an estimate of 0 Euros for each lost year of human life, then the positive economic effect of smoking in our study would have been even larger than the effect estimated by Little. However, when considering the implications of these results, the major question is whether or not humans are to bevalued as commodities, like domesticated animals, or does human life maintain an inherent value even when the individual is not longer economically productive, as in retirement? In the field of health care, it is generally assumed that all human life – even that of the old and disabled – is precious and has value. This view is also currently accepted by national authorities throughout most of the modern world. Already in 1999, 387 billion USD was used in the U.S. for medical treatment and care of people older than 65 years.[30] Nowadays it is generally agreed that the monetary value of one additional life year of a healthy human being is about 20,000-30,000 British Pounds when additional costs of medical care are considered.[27] One may ask why societies continue to invest even larger amounts of money and other social resources to achieve a longer mean life span for citizens, while a more drastic increase could be achieved administratively, without any further costs, by substantially raising tobacco taxes and otherwise restricting access to smoking? There are two likely answers: either governmental authorities have not realized this fact, or they have realized it, but do not want to increase life expectancy due to a subsequent increase in both health care and pension costs.

While denying access to medical care for older people, in order to prevent a deficit in national economy, would not be possible because of common ethical concerns and public opinion, preventing a decrease in smoking rates essentially has the same effect, and is apparently more accepted by many societies. If this is the case, it would also explain the reluctance of governments to regulate the eating and other consumption habits of that negatively affect the general population by, for example, increasing the value added tax (VAT) on food products that are high in sugar and saturated fats, and decreasing VAT on fruits and vegetables, for example. The Czech prime minister stated in 2001 that smoking is beneficial for the state, because smokers die sooner.[17,18] Such comments have not been echoed by other state leaders since, however it is plausible that this view still influences tobacco policies in many modern countries. Therefore, governments should be transparent concerning which kind of knowledge their tobacco and food taxation policy is based on.

Our study cannot answer the question on why cigarette taxes are still low in many countries. Therefore, this remains open and a topic for further research.

The strength of this study is based on empirical data that was gathered from a 27-year prospective study. Thus, no assumptions on healthcare, pension costs or discount percentages of future costs were needed. One shortcoming is that this study did not include females, and it did not include visits to general practitioners, home nursing, or medication and dental care costs in outpatient care, which contribute to about 20–30% of the total health care costs among elderly and middle aged people in Finland.[25] In a previous 19-year follow-up study, it was observed that while the overall healthcare costs were higher among smokers aged 25–59 years, the costs of medication in outpatient care did not differ between smokers and non-smokers.[31] Thus it can be further estimated that the total health care costs might have been at the most about 6,000 to 7,000 Euros higher per individual among non-smokers when compared with smokers, instead of our modest estimate of about 5,000 Euros per individual. However, the magnitude of this difference (€ 1,000–2,000) is less than 2% of the pension costs, and does not have any substantial effect on these results. We also did not include the costs of fires or littering related to smoking, as this information was not available, yet the combined contribution of these factors is probably less than 1% of the total costs.[12] Since only 17% of the initiated subjects refused to participate, the generalisability of results can be considered quite sufficient.

It was presumed that smokers' lower education level and lower income level were not caused by smoking, and that differences in these characteristics were associated with smoking due to the fact that less educated individuals are more likely to start smoking than individuals with higher educational level. Therefore, it was assumed that smoking cessation would not substantially increase education level or income. It can be estimated that during a productive career of about 35 years, with an annual difference of € 2,970 in paid income taxes, smokers in our study have paid an average about 100,000 Euros less income taxes than non-smokers. If it were assumed that early smoking cessation would change these variables to the same levels as with non-smokers, the net difference between smokers vs. non-smokers would shift from € 134,000 to about € 30,000 in favour of smoking, if the value of life years lost are not included, and from € 70,000 to about € 170,000 in favour of non-smoking if the value of life years lost are included in the analysis.

Either way, the principal conclusions on the net costs would remain the same. It is questionable if the tobacco taxes should be considered as beneficial increases in income to the state. For example, if an individual would not have been smoking, then he/she probably would have consumed more goods in the extra years of life and thus paid more taxes for those goods instead of the taxes paid for cigarettes. Overall, the estimate of a € 70,000 beneficial effect of early smoking cessation per individual is probably an underestimate.

Article summary

1) Article Focus

- No results have been obtained from prospective individual level data based on mortality, morbidity, pension and health care costs and, therefore, the net economic impact of smoking on society has remained unclear.

2) Key Messages

- Both the healthcare and pension costs are lower for smokers than non-smokers, the overall difference being more than 100,000 euros per individual.
- However, when a monetary value for life years lost was taken into account, the beneficial net effect of non-smoking to society was about €70,000 per individual.

3) Strengths and Limitations

- This study provides the first evidence for the net economic effect of smoking vs. non-smoking on costs related to health and social welfare, based on prospective data from individual subjects.
- Only males were included in study.

Funding/Support: This project was funded by the Ministry of Health and Social Affairs (Finland), the National Institute for Health and Welfare (THL) and the Academy of Finland. The funders were not involved in the conduct of the study, or in the collection, management, analysis or interpretation of the data.

Competing Interest: All authors have completed the Unified Competing Interest form at www.icmj.org.coi_disclosure.pdf (available on request from the corresponding author) and declare: Dr Tiihonen is a member of advisory board of AstraZeneca and Janssen-Cilag, and he reports serving as a consultant to Lundbeck, Organon, Janssen-Cilag, Eli Lilly, AstraZeneca, F. Hoffman-La Roche, and Bristol-Myers Squibb. He has received fees for giving expert opinions to Bristol-Myers Squibb and GlaxoSmithKline, and lecture fees from Janssen-Cilag, Bristol Myers-Squibb, Eli Lilly, Pfizer, Lundbeck, GlaxoSmithKline, Novartis, and Astra Zeneca. No further disclosures were reported.

Contributors: JT, KR and JK had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. JT wrote the first draft of the manuscript and all other authors read and had input in the final version of the paper. JT did study concept and design, KR and JK collected data, KR did statistical analysis and KR produced figures. JT is the guarantor.

Ethical approval: The KIHD study was approved by the Research Ethics Committee of the University of Kuopio, in Kuopio, Finland.

Data sharing: No additional data available.

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Figure legends

Figure 1. Average annual health care costs per living individual, in Euros, as a function of age.

Figure 2. Average annual health care costs among all individuals in Euros (including deceased persons).

Table 1. Cause-specific mortality among smokers and non-smokers.

Cause of death	Non-smokers (%)	Smokers (%)
Cardiovascular disease	267 (48%)	166 (47%)
Cancer (all)	146 (26%)	102 (29%)
Lung cancer	15 (3%)	47 (13%)
Respiratory disease	13 (2%)	20 (6%)
External causes of death	56 (10%)	28 (8%)
Other	71 (13%)	35 (10%)
Total	553 (100%)	351 (100%)

A total of 553 (37.3%) non-smokers and 351 (71.2%) smokers had died during the follow-up. Percentages indicate the proportions for cause of death from all deaths in each group. Cancer deaths include lung cancer deaths.

Table 2. Smoking-related outcomes.

	Non-smokers N=1483		Smokers N=493			
	Mean	S.D.	Mean	S.D.	Difference of means	p-value
Age at baseline, years	55.72	2.50	55.54	2.38	-0.2	0.17
Body mass index (BMI)	27.29	3.51	26.01	3.81	-1.3	< 0.001
Mean systolic blood pressure (mm Hg)	135.93	17.43	133.43	18.18	-2.5	0.007
LDL-cholesterol (mmol/l)	4.07	1.01	4.21	1.09	0.1	0.013
Years of education	8.19	3.32	7.52	2.74	-0.7	< 0.001
Age at death, years	80.71	8.40	72.13	8.89	-8.6	< 0.001
Life years lost due to smoking	0	0	9.19	8.15	9,2	< 0.001
Age at retirement, years	56.60	5.89	55.35	6.23	-1.3	< 0.001
Years of receiving pension	23.69	9.11	16.42	9.39	-7.3	< 0.001
Number of hospitalizations	10.74	12.34	10.84	10.89	0.1	0.88
Number of inpatient days	88.47	235.25	101.55	216.23	13.1	0.28
Years of smoking (at baseline)	2.69	8.96	31.81	9.72	29.1	< 0.001
Annual income, €	34,060	22,180	27,510	17.730	-6,550	< 0.001
Occupational productivity lost due to smoking, €	0	0	34,370	27,080	34,370	< 0.001
Income taxes lost due to smoking, €	0	0	11,660	12,550	11,660	< 0.001
Annual pension, €	20,440	13,330	16,180	9,730	-4,260	< 0.001
Reduced pension costs due to smoking,€	0	0	126,850	148,120	126,850	< 0.001
Reduced income taxes paid from pensions, €	0	0	34,230	48,650	34,230	< 0.001
Annual health care costs/living individuals, €	3,420	9,870	5,040	10,650	1,620	0.003
Total health care costs, €	79,290	173,420	74,570	154,950	-4,720	0.59
Tobacco tax paid, €	2,190	8,860	50,300	32,450	48,110	< 0.001
Life years lost due to smoking, €	0	0	203,960	180,890	203,960	<0.001
Total costs, life years lost not included, €	77,110	173,840	-56,680	195,130	-133,790	< 0.001
Total costs, life years lost included, €	77,110	173,840	147,280	195,960	70,170	<0.001

Total costs of smoking vs. non-smoking were calculated by taking into account the life-long difference (€/person) of health care costs (€ 4,720), tobacco taxes paid (€ 48,110), income taxes lost (€ 11,660), reduced pension costs (€ 126,850), and reduced taxes paid from pensions (€ 34,230). The smoking-related harms for the society were € 11,660 + € 34,230 = € 45,890, and the smoking-related benefits for the society were € 4,720 + € 48,110 + € 126,850 = € 179,680, and thus the net effect on public finance balance was € 133,790 positive for each smoking individual. When the value of 9.19 life years lost due to smoking (€ 203,960) was taken into account, the net effect became € 70,170 negative for each smoking individual. “Income taxes lost due to smoking” indicate the loss due to earlier disability/retirement, and “Pension costs” indicate the pensions paid by the state and pension companies. The value of one quality adjusted life year lost was estimated to be 0.74 x € 30,000 = € 22,200.[10,25]

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The Net Effect of Smoking on ~~and~~ Healthcare and Welfare Costs. A Cohort Study.

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Abstract

Objective: To study the net economic effect of smoking on society.

Design, Setting, and Patients: We studied mortality, paid income and tobacco taxes, and the cumulative costs due to pensions and medical care among both tobacco smoking and non-smoking individuals in a 27-year prospective cohort study of 1,976 men from Eastern Finland. These individuals were 54–60 years old at the beginning of the follow-up.

Main Outcome Measures: The net contribution of smoking vs. non-smoking individuals to public finance balance (euros).

Results: Smoking was associated with a greater mean annual health care cost of €1,600 per living individual during follow-up. However, due to a shorter life span of 8.6 years, smokers' mean total healthcare costs during the entire study period were actually €4,700 lower than for non-smokers. For the same reason, each smoker missed 7.3 years (€126,850) of pension. Overall, smokers' average net contribution to the public finance balance was €133,800 greater per individual compared with non-smokers. However, if each lost quality adjusted life year is considered to be worth €22,200, the net effect is reversed to be €70,200 (€ 71.600 when adjusted with propensity score) per individual in favour of non-smoking.

Conclusion: Smoking was associated with a moderate decrease in health care costs, and a marked decrease in pension costs due to increased mortality. However, when a monetary value for life years lost was taken into account, the beneficial net effect of non-smoking to society was about €70,000 per individual.

Introduction

Smoking is the single most important preventable cause of premature death in industrialized countries[1], and tobacco taxation is still the most cost-effective method for decreasing the prevalence of smoking. Increases in tobacco taxes have encouraged 9 to 17% of smokers to quite[2,3], and in the long run the main effect of taxation is a reduction in the incidence of new young smokers.[4] Early smoking cessation increases lifespan by about 9-10 years,[5] and if the smoking rate diminished by 10 percentage points, life expectancy would increase by about one year. It has been estimated that a 10% increase in the price of smoked tobacco will result in about a 5% decrease in cigarette consumption,[4] yet tobacco taxes are still low in many countries. Thus, it would be interesting to know why so many governments in the world continue to increase spending on health care costs, while a substantial savings and advances in life expectancy are readably available by administratively increasing tobacco taxes? There are two plausible explanations: the governments do not know about the correlation between increasing tobacco taxes on increasing life expectancy, or they realize this effect, but do not want to increase the life expectancy. One possible explanation is that governments are reacting to pressure from cigarette companies and smokers (either implicit or explicit) which prevents tax increases.

The net effect of smoking on healthcare costs has been investigated in several studies.[6-18] Some modelling studies have suggested that while smokers suffer more from many kinds of diseases, non-smokers incur more healthcare costs because they live longer,[6,7,8,11,12] yet others have reached the opposite conclusion.[9,10,13-18] Only few of these studies have included both pension and insurance costs,[7,12,17,18] and paid tobacco taxes.[12,17,18] In 2001, Philip Morris provided a report to the Government of the Czech Republic, which indicated that the effect of smoking on the public finance balance in the Czech Republic in 1999 was positive and estimated to be 5,815 million korunas (about 150 million USD).[12] Although this report generated outraged reactions worldwide, Milos Zeman, the Czech prime minister stated “As a smoker, I support the state budget, because in the Czech Republic, we pay tax on tobacco. Also, smokers die sooner, and the state does not need to look after them in their old age”. [19,20] This report was based on many assumptions that were obtained through theoretical modelling, and it did not give any monetary value for life years lost

because of smoking, and it was claimed to have underestimated the costs of medical care for people suffering from smoking related diseases.[21] The overall net effect of smoking on private (personal) and external costs has been studied also by Sloan et al[17] and Viscusi[18], who used US lifetable data to model the forth-coming lifelong net costs caused by smoking. As shown by van Baal et al., slightly different models can give markedly different results on the net effect of smoking, depending what assumptions are used[22]. In any case, sophisticated incidence-based datasets are ultimately required to establish the true health care costs incurred by smoking.[23] Because no results have been obtained from prospective, individual level data based on mortality, morbidity, pension and health care costs, the net economic impact of smoking on society has remained unclear. The aim of this study was to investigate this net economic effect by using data from a prospective 27-year follow-up of a cohort of 1,976 Finnish middle-aged men.

Methods

Study population

The subjects of the Kuopio Ischemic Heart Disease study (KIHD) were obtained from a randomly selected sample of 3,433 men, aged 42 to 60 years, who resided in the town of Kuopio or its surrounding rural communities. Of those invited, 2,682 (83 %) participated in the study. Of these, individuals from 54 to 60 years with complete data for smoking, income, healthcare costs, retirement, and mortality (n=1,976 men) were included in the final analyses. The baseline examinations were conducted between March 1984 and December 1989.[24] The mean follow-up time was 24.2 years (range 21.1±26.8 years). The KIHD study was approved by the Research Ethics Committee of the University of Kuopio, in Kuopio, Finland. Each participant gave written informed consent. The end of follow-up period was December 31, 2010.

A subject was defined as a smoker if he had ever smoked on a regular basis, and had smoked cigarettes, cigars, or a pipe within the past 30 days. The lifelong exposure to smoking ("cigarette pack-years") was estimated as the product of years smoked and the number of tobacco products smoked daily at the time of examination. "Years smoked" were defined as the sum of years of smoking regardless of when smoking had started,

whether the subject had stopped smoking, or whether it had occurred continuously or during several periods. Data on mortality was obtained from Statistics Finland, and data on healthcare costs from the Finnish Institute for Health and Welfare (THL). The health care costs did not include visits to general practitioners, home nursing, or medication and dental care costs in outpatient care, which have been estimated to be about 20–30% of total health care costs in this age group in Finland.[25] The amount of paid tobacco taxes was estimated on the basis of cigarette pack-years,[26] and the amount of paid income taxes was estimated by using the income tax rate of year 1987. The amount of occupational productivity and income taxes lost was calculated as the difference of age at retirement (relative to the retirement age of matched non-smokers) multiplied by the annual income and income tax of each smoker. “Income taxes paid” also included obligatory pension and healthcare insurance fees. All monetary values were expressed as Euros (€) and converted to the level of year 2009.

In the United Kingdom, the monetary value of one quality adjusted life year (QALY) has been estimated to be 20,000–30,000 Pounds for an individual having perfect health.[27] In the present study, we used a value of 30,000 Euros (about 25,100 Pounds in February 2012). In a recent large study on the effect of smoking on life expectancy, the quality-of-life score among former smokers with a BMI of 25–30, who were older than 65-years was estimated to be 0.71–0.77.[28] Therefore, we used a quality-of-life score of 0.74 for smokers in the present study, thus equalling to 0.74 x 30,000 Euros = 22,200 Euros for each life year lost due to smoking among former smokers aged over 65 years (deceased smokers who would be over 65 if they had lived).

Statistical analysis

Differences in baseline characteristics and costs were examined using the Student’s t-test. Descriptive data are presented as means and percentages. A p-value of less than 0.05 was considered statistically significant. These statistical analyses were performed using SPSS 17.0 for Windows. Life expectancy for those individuals still alive on 31st December 2009 was calculated by using life expectancy from the Life Table provided by Statistics Finland.[29]

Adjusted group difference in total cost was assessed also using bootstrap type analysis of covariance (ANCOVA) with adjustments for the propensity score. Potential variables for inclusion in the propensity score (age at baseline, BMI, systolic blood pressure, LDL-cholesterol and years of education) were explored in logistic regression with a backward selection procedure (P<0.25 as selection criterion). Patients were stratified based on quintiles of the propensity score. Furthermore, the fit of the propensity score model was assessed by the Hosmer–Lemeshow test.

Results

The crude mortality rates were 351/493 (71.2%) among smokers, and 553/1483 (37.3%) among non-smokers, and the cause-specific mortality in each group is shown in Table 1. The observed age at death was 67.8 years for smokers, and 71.4 years for non-smokers. The predicted mean age at death was 72.1 for smokers and 80.7 years for non-smokers, indicating 8.6 years difference between two groups. When the effect of birth year on life expectancy was taken into account, the amount of life years lost due to smoking was 9.2 years. The demographic variables and smoking-related outcomes are shown in Table 2. Smokers had substantially lower mean BMI and educational level. Smokers also had a slightly lower mean systolic blood pressure and a slightly higher mean LDL cholesterol level. Smoking was associated with a moderate decrease in productive occupational career, income taxes paid, and hospital care costs, and showed a marked decrease in pension costs. The net effect of smoking on public finance was plus € 133,800 for these smokers during the follow-up when life years lost were not included, and minus € 70,200 when a monetary value for life years lost was included in the calculation. When propensity score method was applied, the result remained almost the same (€ 71.600, 95%CI € 52.300 to € 90.800).

Figure 1 demonstrates the average annual healthcare costs as a function of age among those individuals still alive, and Figure 2 shows the corresponding results when all individuals (also deceased) are included. The higher mortality results into lower annual costs among smokers after 72 years from birth.

Discussion

Hospital care costs were 1,600 Euros greater per person year for living individuals among the smokers during the follow-up, but due to a 8.6 year shorter life span, the total costs per individual were 4,700 Euros lower among smokers than non-smokers during the entire study period. This study provides the first evidence for the net economic effect of smoking vs. non-smoking on costs related to health and social welfare, based on prospective, individual level data.

Smoking resulted in a moderate decrease in the productive occupational career and income taxes and pension fees paid, a moderate decrease in health care costs, and a marked decrease in the pension costs. The costs of smoking to society have been modelled by using estimates on increased mortality and morbidity.[6-18] However, none of these modelling studies investigated the overall net economic effect of smoking on public finance balance by using actual data from individuals, and only few had taken into account all of the following factors; lifetime productivity or income taxes and pension fees paid, pension costs, and a monetary value of life years lost.[17,18] Our results indicate that combined, these factors make considerable contribution to the overall net effect than merely health care costs which is in line with the modelling studies by Sloan et al.[17] and Viscosi[18]. If the potential increase in quality adjusted life years is taken into account, our results suggest that the life long net beneficial economic effect of early smoking cessation is more than € 70,000 per individual, and this sum did not change substantially when propensity score was applied in the analysis. Our results also indicate that reducing the rate of smoking has a huge beneficial economic effect on society, mainly due to increased life span and continued pension costs. In Finland, the National Institute for Health and Welfare aims to make Finland free of smoking by the year 2040. Since there are currently about 900,000 smokers in Finland, the average net effect of € 134,000 per individual on public finance balance (without taking into account the monetary value of life years lost) would correspond during the next decades to about 120 billion Euros total increase in costs (over 2.5-fold to annual state budget). However, this nominal deficit would be massively outweighed by about 2 years increase in life expectancy of the whole nation.

Our overall results on the net economic effect of smoking on public finance balance are contrary to the Philip Morris report. A major reason for this difference is that Little did not

consider the inherent value of the quality adjusted life years lost. In other words, if we used an estimate of 0 Euros for each lost year of human life, then the positive economic effect of smoking in our study would have been even larger than the effect estimated by Little. However, when considering the implications of these results, the major question is whether or not humans are to bevalued as commodities, like domesticated animals, or does human life maintain an inherent value even when the individual is not longer economically productive, as in retirement? In the field of health care, it is generally assumed that all human life – even that of the old and disabled – is precious and has value. This view is also currently accepted by national authorities throughout most of the modern world. Already in 1999, 387 billion USD was used in the U.S. for medical treatment and care of people older than 65 years.[30] Nowadays it is generally agreed that the monetary value of one additional life year of a healthy human being is about 20,000-30,000 British Pounds when additional costs of medical care are considered.[27] One may ask why societies continue to invest even larger amounts of money and other social resources to achieve a longer mean life span for citizens, while a more drastic increase could be achieved administratively, without any further costs, by substantially raising tobacco taxes and otherwise restricting access to smoking? There are two likely answers: either governmental authorities have not realized this fact, or they have realized it, but do not want to increase life expectancy due to a subsequent increase in both health care and pension costs.

While denying access to medical care for older people, in order to prevent a deficit in national economy, would not be possible because of common ethical concerns and public opinion, preventing a decrease in smoking rates essentially has the same effect, and is apparently more accepted by many societies. If this is the case, it would also explain the reluctance of governments to regulate the eating and other consumption habits of that negatively affect the general population by, for example, increasing the value added tax (VAT) on food products that are high in sugar and saturated fats, and decreasing VAT on fruits and vegetables, for example. The Czech prime minister stated in 2001 that smoking is beneficial for the state, because smokers die sooner.[17,18] Such comments have not been echoed by other state leaders since, however it is plausible that this view still influences tobacco policies in many modern countries. Therefore, governments should be transparent concerning which kind of knowledge their tobacco and food taxation policy is based on.

Our study cannot answer the question on why cigarette taxes are still low in many countries. Therefore, this remains open and a topic for further research.

The strength of this study is based on empirical data that was gathered from a 27-year prospective study. Thus, no assumptions on healthcare, pension costs or discount percentages of future costs were needed. One shortcoming is that this study did not include females, and it did not include visits to general practitioners, home nursing, or medication and dental care costs in outpatient care, which contribute to about 20–30% of the total health care costs among elderly and middle aged people in Finland.[25] In a previous 19-year follow-up study, it was observed that while the overall healthcare costs were higher among smokers aged 25–59 years, the costs of medication in outpatient care did not differ between smokers and non-smokers.[31] Thus it can be further estimated that the total health care costs might have been at the most about 6,000 to 7,000 Euros higher per individual among non-smokers when compared with smokers, instead of our modest estimate of about 5,000 Euros per individual. However, the magnitude of this difference (€ 1,000–2,000) is less than 2% of the pension costs, and does not have any substantial effect on these results. We also did not include the costs of fires or littering related to smoking, as this information was not available, yet the combined contribution of these factors is probably less than 1% of the total costs.[12] Since only 17% of the initiated subjects refused to participate, the generalisability of results can be considered quite sufficient.

It was presumed that smokers' lower education level and lower income level were not caused by smoking, and that differences in these characteristics were associated with smoking due to the fact that less educated individuals are more likely to start smoking than individuals with higher educational level. Therefore, it was assumed that smoking cessation would not substantially increase education level or income. It can be estimated that during a productive career of about 35 years, with an annual difference of € 2,970 in paid income taxes, smokers in our study have paid an average about 100,000 Euros less income taxes than non-smokers. If it were assumed that early smoking cessation would change these variables to the same levels as with non-smokers, the net difference between smokers vs. non-smokers would shift from € 134,000 to about € 30,000 in favour of smoking, if the value of life years lost are not included, and from € 70,000 to about € 170,000 in favour of non-smoking if the value of life years lost are included in the analysis.

Either way, the principal conclusions on the net costs would remain the same. It is questionable if the tobacco taxes should be considered as beneficial increases in income to the state. For example, if an individual would not have been smoking, then he/she probably would have consumed more goods in the extra years of life and thus paid more taxes for those goods instead of the taxes paid for cigarettes. Overall, the estimate of a € 70,000 beneficial effect of early smoking cessation per individual is probably an underestimate.

Article summary

1) Article Focus

- No results have been obtained from prospective individual level data based on mortality, morbidity, pension and health care costs and, therefore, the net economic impact of smoking on society has remained unclear.

2) Key Messages

- Both the healthcare and pension costs are lower for smokers than non-smokers, the overall difference being more than 100,000 euros per individual.
- However, when a monetary value for life years lost was taken into account, the beneficial net effect of non-smoking to society was about €70,000 per individual.

3) Strengths and Limitations

- This study provides the first evidence for the net economic effect of smoking vs. non-smoking on costs related to health and social welfare, based on prospective data from individual subjects.
- Only males were included in study.

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Competing Interest: All authors have completed the Unified Competing Interest form at www.icmj.org.coi_disclosure.pdf (available on request from the corresponding author) and declare: Dr Tiihonen is a member of advisory board of AstraZeneca and Janssen-Cilag, and he reports serving as a consultant to Lundbeck, Organon, Janssen-Cilag, Eli Lilly, AstraZeneca, F. Hoffman-La Roche, and Bristol-Myers Squibb. He has received fees for giving expert opinions to Bristol-Myers Squibb and GlaxoSmithKline, and lecture fees from Janssen-Cilag, Bristol Myers-Squibb, Eli Lilly, Pfizer, Lundbeck, GlaxoSmithKline, Novartis, and Astra Zeneca. No further disclosures were reported.

Contributors: JT, KR and JK had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. JT wrote the first draft of the manuscript and all other authors read and had input in the final version of the paper. JT did study concept and design, KR and JK collected data, KR did statistical analysis and KR produced figures. JT is the guarantor.

Ethical approval: The KIHD study was approved by the Research Ethics Committee of the University of Kuopio, in Kuopio, Finland.

Data sharing: No additional data available.

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Figure legends

Figure 1. Average annual health care costs per living individual, in Euros, as a function of age.

Figure 2. Average annual health care costs among all individuals in Euros (including deceased persons).

Table 1. Cause-specific mortality among smokers and non-smokers.

Cause of death	Non-smokers (%)	Smokers (%)
Cardiovascular disease	267 (48%)	166 (47%)
Cancer (all)	146 (26%)	102 (29%)
Lung cancer	15 (3%)	47 (13%)
Respiratory disease	13 (2%)	20 (6%)
External causes of death	56 (10%)	28 (8%)
Other	71 (13%)	35 (10%)
Total	553 (100%)	351 (100%)

A total of 553 (37.3%) non-smokers and 351 (71.2%) smokers had died during the follow-up. Percentages indicate the proportions for cause of death from all deaths in each group. Cancer deaths include lung cancer deaths.

Table 2. Smoking-related outcomes.

	Non-smokers N=1483		Smokers N=493			
	Mean	S.D.	Mean	S.D.	Difference of means	p-value
Age at baseline, years	55.72	2.50	55.54	2.38	-0.2	0.17
Body mass index (BMI)	27.29	3.51	26.01	3.81	-1.3	< 0.001
Mean systolic blood pressure (mm Hg)	135.93	17.43	133.43	18.18	-2.5	0.007
LDL-cholesterol (mmol/l)	4.07	1.01	4.21	1.09	0.1	0.013
Years of education	8.19	3.32	7.52	2.74	-0.7	< 0.001
Age at death, years	80.71	8.40	72.13	8.89	-8.6	< 0.001
Life years lost due to smoking	0	0	9.19	8.15	9,2	< 0.001
Age at retirement, years	56.60	5.89	55.35	6.23	-1.3	< 0.001
Years of receiving pension	23.69	9.11	16.42	9.39	-7.3	< 0.001
Number of hospitalizations	10.74	12.34	10.84	10.89	0.1	0.88
Number of inpatient days	88.47	235.25	101.55	216.23	13.1	0.28
Years of smoking (at baseline)	2.69	8.96	31.81	9.72	29.1	< 0.001
Annual income, €	34,060	22,180	27,510	17.730	-6,550	< 0.001
Occupational productivity lost due to smoking, €	0	0	34,370	27,080	34,370	< 0.001
Income taxes lost due to smoking, €	0	0	11,660	12,550	11,660	< 0.001
Annual pension, €	20,440	13,330	16,180	9,730	-4,260	< 0.001
Reduced pension costs due to smoking,€	0	0	126,850	148,120	126,850	< 0.001
Reduced income taxes paid from pensions, €	0	0	34,230	48,650	34,230	< 0.001
Annual health care costs/living individuals, €	3,420	9,870	5,040	10,650	1,620	0.003
Total health care costs, €	79,290	173,420	74,570	154,950	-4,720	0.59
Tobacco tax paid, €	2,190	8,860	50,300	32,450	48,110	< 0.001
Life years lost due to smoking, €	0	0	203,960	180,890	203,960	<0.001
Total costs, life years lost not included, €	77,110	173,840	-56,680	195,130	-133,790	< 0.001
Total costs, life years lost included, €	77,110	173,840	147,280	195,960	70,170	<0.001

Total costs of smoking vs. non-smoking were calculated by taking into account the life-long difference (€/person) of health care costs (€ 4,720), tobacco taxes paid (€ 48,110), income taxes lost (€ 11,660), reduced pension costs (€ 126,850), and reduced taxes paid from pensions (€ 34,230). The smoking-related harms for the society were € 11,660 + € 34,230 = € 45,890, and the smoking-related benefits for the society were € 4,720 + € 48,110 + € 126,850 = € 179,680, and thus the net effect on public finance balance was € 133,790 positive for each smoking individual. When the value of 9.19 life years lost due to smoking (€ 203,960) was taken into account, the net effect became € 70,170 negative for each smoking individual. “Income taxes lost due to smoking” indicate the loss due to earlier disability/retirement, and “Pension costs” indicate the pensions paid by the state and pension companies. The value of one quality adjusted life year lost was estimated to be 0.74 x € 30,000 = € 22,200.[10,25]

Figure 1. Average annual health care costs per living individual, in Euros, as a function of age.

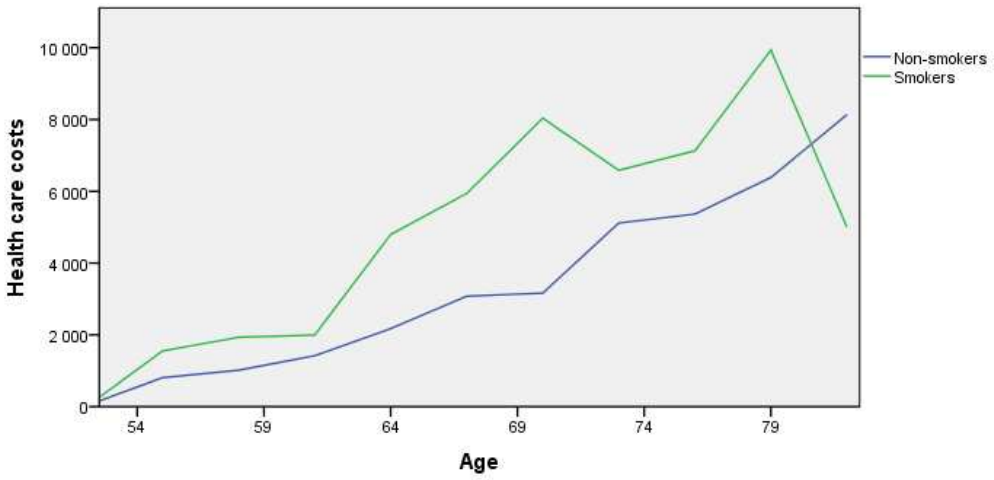
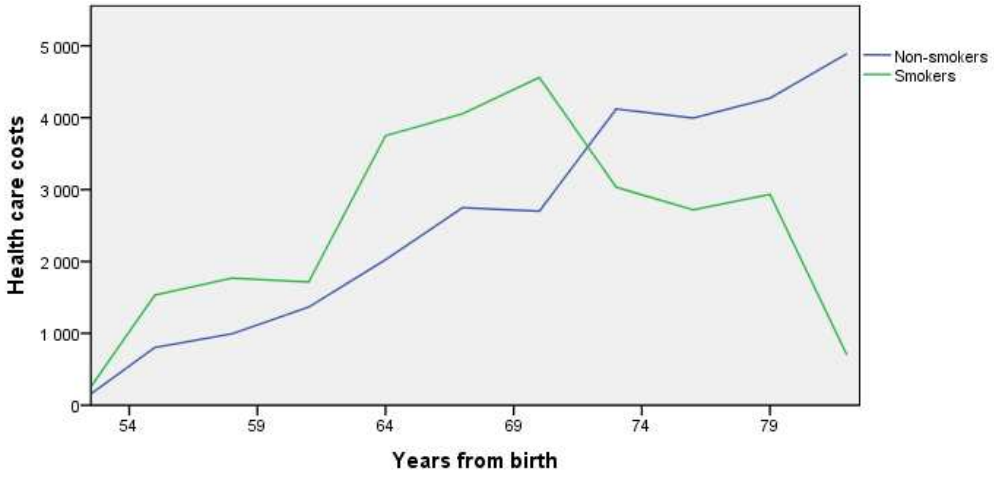


Figure 2. Average annual health care costs among all individuals in Euros (including deceased persons).



STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1 Done	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2 pp. 3,4	Explain the scientific background and rationale for the investigation being reported
Objectives	3 p. 4	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4 p. 4	Present key elements of study design early in the paper
Setting	5 p. 4	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 pp. 4,5	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7 pp. 4,5	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8* pp.4,5	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 Not done	Describe any efforts to address potential sources of bias
Study size	10 p. 4	Explain how the study size was arrived at
Quantitative variables	11 pp. 4,5	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 p. 5	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed No missing data
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13* p. 4	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage No drop-outs or missing data
		(c) Consider use of a flow diagram
Descriptive data	14* Done	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Table 2
		(b) Indicate number of participants with missing data for each variable of interest No missing data
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount) p. 4
Outcome data	15* Done	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures Tables 1 and 2
Main results	16 Done	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses No such analyses
Discussion		
Key results	18 pp. 6, 7	Summarise key results with reference to study objectives
Limitations	19 pp. 8, 9	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20 p. 9	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21 p. 9	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22 p. 11	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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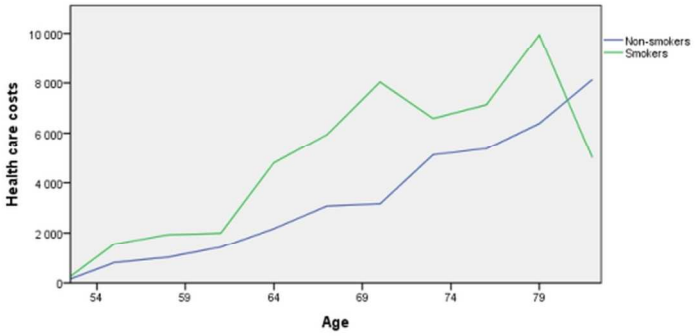

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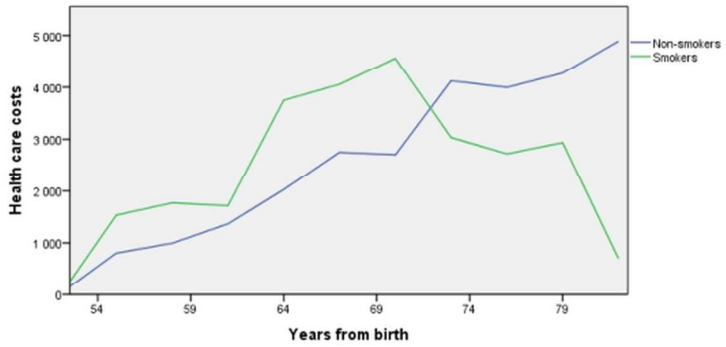
Figure 2. Average annual health care costs among all individuals in Euros (including deceased persons).



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