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Educational differences in lung cancer mortality in male smokers

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Background To assess the extent of lung cancer mortality differentials by education while adjusting for exposure to tobacco smoke and asbestos based on survey questions.

Methods Alpha-Tocopherol, Beta Carotene Cancer Prevention (ATBC) Study of 50–69-year-old Finnish male smokers enrolled 1985–1988. These analyses are based on the placebo group and the alpha-tocopherol supplementation group, altogether 14 011 men, with full information on tobacco smoking. Mortality follow-up was to the end of April 1993 and it was based on the complete death certificate register of the Statistics Finland.

Results Lung cancer mortality of basic-educated men was 32% (rate ratio [RR] = 1.32; 95% CI : 0.93–1.87) higher than that of better-educated men in the ATBC Study. The excess is practically unchanged when additional adjustment was made for age at initiation, duration of smoking, current smoking at baseline and at first follow-up, smoke inhalation, occupational exposure to asbestos and interactions between asbestos exposure and all smoking variables. This excess mortality was about 40% of the similar excess observed in the general population of men of similar age.

Conclusions Educational differences in lung cancer mortality in the total Finnish population are likely to be mainly caused by differences in exposure, particularly to active smoking. Further understanding of the determinants and consequences of socioeconomic differences in smoking behaviour are of major scientific and public health importance.

Keywords Lung cancer, mortality, education, smoking, confounding

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Lung cancer mortality differentials by socioeconomic status are observed in numerous countries.[1] These studies often show that people with lower socioeconomic status have higher lung cancer mortality than those with higher status. The most obvious explanation for these differentials is that those with lower socioeconomic status smoke more. Extensive evidence exists that about 98% of all male lung cancer deaths occur among those who have smoked.[2,3] Estimates from Finland indicate that about 86% of lung cancer deaths among men could be avoided if smoking were eliminated.[4]

However, socioeconomic differences in lung cancer mortality seem to persist within different levels of current smoking and among ex-smokers.[5,6] This observation suggests that lung cancer mortality differentials cannot be explained by exposure to tobacco smoke, and that the reasons behind high mortality in lower socioeconomic groups lie in, for example, greater general susceptibility[6] or adverse psychosocial environment.

The persistence of lung cancer mortality differentials could also be due to inadequate adjustment for smoking and to specific occupational exposures. Total lifetime exposure to tobacco smoke cannot necessarily be accurately assessed by survey questions regarding current levels of smoking. Potential for uncontrolled or residual confounding[7] may therefore be substantial.

The purpose of this study was (1) to assess the extent of lung cancer mortality differentials by education while restricting the analyses to a cohort of heavy smoking men and adjusting for, as accurately as possible, exposure to tobacco smoke and asbestos based on survey questions in study baseline and first follow-up,

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(2) to compare this excess mortality to the corresponding excess observed in the general male population of the same age.

Materials and Methods

The analyses were based on two data sets. The primary data come from the Alpha-Tocopherol, Beta Carotene Cancer Prevention (ATBC) Study, a randomized placebo-controlled prevention trial to examine whether supplementation with alpha-tocopherol and beta carotene can reduce the incidence of lung cancer among male smokers.[8] The participants were recruited in 1985–1988 from the total 50–69-year-old male population in 14 designated areas in South-Western Finland. To participate, respondents to a mailed questionnaire had to be current smokers (>5 cigs/day) willing to participate with written consent. In succeeding clinical visits those with a history of cancer or serious disease limiting their ability to participate, those taking supplements of vitamin E, vitamin A, or beta carotene in excess of predefined doses, and those treated with anticoagulant agents were excluded. The participants were randomly assigned in a two-by-two factorial design to the following supplementation groups: (1) alpha-tocopherol, (2) beta carotene, (3) alpha-tocopherol and beta carotene, and (4) placebo group. The study design has been described more fully elsewhere.[8]

The analyses presented in this study are based on the participants of the alpha-tocopherol alone and placebo groups who participated in the first follow-up 4 months after trial enrolment and had full information on all aspects of exposure to tobacco; altogether 14 011 men. Full information on smoking history was missing for less than 4% of people. The levels of risk factors for lung cancer were similar in the alpha-tocopherol and placebo groups at baseline. Also lung cancer mortality differences between these two groups were very small. However, those receiving beta carotene supplementation were not analysed here because beta carotene supplementation was observed to possibly increase lung cancer mortality.[9]

At baseline, questionnaire information was obtained on socio-demographic characteristics, medical examinations and disease. For the purposes of this study the six-level educational attainment variable, the key socioeconomic variable of interest, was categorized as basic education (elementary school or less) or higher education (more than elementary school). In this cohort basic education is less than 7 years.

In order to obtain reliable information on smoking exposure, we used information on smoking collected at baseline as well as the first follow-up (4 months from the baseline interview). The following questions on smoking were used:

(1) *Age at initiation*: 'At what age did you start regular smoking (that is smoked every day or almost every day for at least a year)?'

(2) *Duration of smoking*: 'How many years have you smoked regularly?'

(3) *Current smoking at baseline and at first follow-up visit* was assessed as the average number of cigarettes smoked daily.

(4) *Smoking inhalation* was categorized into four groups: always, most of the time, seldom and never.

In addition, occupational exposure to asbestos was assessed at baseline by asking the participants about ever being employed in asbestos mining, asbestos production and asbestos insulating occupations.

Mortality follow-up began after the first follow-up visit and was based on the complete death certificate register of the Statistics Finland. For the purposes of this study mortality follow-up continued until the end of April 1993. The average duration of follow-up was 5.5 years.

The second data set is based on the 1985 census records of all Finnish men[10] resident in the ATBC recruitment areas, with mortality follow-up based on the same source as the ATBC Study. In order to obtain the same average duration of follow-up in the national data as in the ATBC data, we started the follow-up of 50–69-year-old men 5.5 years before April 1993.

In the national data information on education is based on the register of educational certificates and thus differs somewhat from the ATBC self-reports of educational qualifications. Basic education in the national data was elementary school or educational qualifications not available. The effects of the different sources of education data on the results are estimated.

We calculated directly age-adjusted mortality rates for the ATBC data and the national data, using the national data in single-year age groups as the standard. Further analyses of the individual level data from the ATBC Study were carried out by means of Cox proportional hazards regression. Poisson regression was used for the tabulated national data. The regression models were fitted with the S-Plus statistical package.[11] The results of the Cox and Poisson regression models were presented as mortality rate ratios (RR) and their 95% CI. The first category of each explanatory variable was the reference group, with an RR of 1.00. In all analyses, age was controlled for in single-year increments. Adjustment for smoking behaviour in the ATBC Study was categorical. For this purpose number of cigarettes at baseline and at first follow-up, duration of smoking and age at initiation were categorized into six equal size groups.

Results

About 79% of the ATBC Study placebo and alpha-tocopherol supplementation group had basic education (Table 1). The median age of smoking initiation among the participants was 19 and they had smoked for about 36 years. In addition, 75% had started smoking before the age of 21 years and 75% had smoked for more than 31 years. Because of the inclusion criteria, all the participants were current smokers at baseline. Levels of current smoking were very high: 75% smoked more than 15 cigarettes a day. More than 90% inhaled tobacco smoke usually or always. Differences in smoking behaviour between the education groups were very small. About 2% of all men had worked in occupations having some exposure to asbestos.

During the follow-up 238 men died of lung cancer. Age-adjusted lung cancer mortality was 32% (95% CI : 0.93–1.87) higher among men having a basic education than among better educated men (Table 2). In addition to age we also adjusted for age at initiation, smoking years, current smoking at baseline and at first follow-up visit, smoking inhalation, asbestos exposure and all interactions between exposure to asbestos and smoking behaviour variables. These adjustments had no effect on the excess lung cancer mortality of basic-educated men.

More men had higher education in the total population (33%) than in the ATBC Study (21%). Age-adjusted excess lung cancer mortality of the basic-educated men in the total 50–69-year-old Finnish population was 82% higher compared to the men with

Table 1 Number of people, and means, intra-quartile ranges (in parentheses) and prevalence of baseline characteristics by level of education. 50–69-year-old smoking men from the Alpha-Tocopherol, Beta Carotene Cancer Prevention (ATBC) Study

	Education		
	Basic	Higher	All
No. of people	11 073	2938	14 011
Age (years)	58 (54,62)	57 (53,60)	58 (53,61)
Age at smoking initiation (years)	19 (17,21)	19 (17,21)	19 (17,21)
Duration of smoking (years)	37 (31,42)	35 (30,40)	36 (31,42)
Current smoking (cigs/day)			
At baseline	20 (15,25)	20 (15,27)	20 (15,25)
At first follow-up	20 (15,25)	20 (15,25)	20 (15,25)
Smoking inhalation (% inhale always or most of the time)	91	91	91
Exposure to asbestos (% exposed)	2	1	2

Table 2 Lung cancer mortality rate ratios and 95% CI by education, 50–69-year-old men from the Alpha-Tocopherol, Beta Carotene Cancer Prevention (ATBC) Study and corresponding men in the national Finnish data

Educational attainment	Person-years (%)	Lung cancer deaths No.	Age-adjusted mortality rate	Mortality rate ratio (95% CI) Age-adjusted	Mortality rate ratio (95% CI) Adjusted for age and other factors[a]
ATBC Study					
Higher	16 656 (21)	38	283	1.00	1.00
Lower	60 871 (79)	200	374	1.32 (0.93–1.87)	1.33 (0.93–1.89)
National data					
Higher	613 267 (33)	652	119	1.00	
Lower	1 242 585 (67)	2827	216	1.82 (1.67–1.98)	

[a] Adjusted for categorical age, duration of smoking, current smoking at base-line and at first follow-up, smoking inhalation, exposure to asbestos and all interactions between exposure to asbestos and smoking behaviour variables.

higher education. Alternative definitions (more lenient) of basic education led into even larger mortality differences (data not shown here). When the basic educational category included those with qualifications from elementary school or less, as well as those with first level of secondary schooling (constituting 81% of all men), the mortality difference was 120%.

Discussion

This study has shown that in the ATBC Study placebo and alpha-tocopherol groups of 50–69-year-old Finnish male smokers, lung cancer mortality of basic-educated men is 32% (RR = 1.32; 95% CI : 0.93–1.87) higher than that of better-educated men. The excess is unchanged when extensive adjustment for smoking at baseline and first follow-up—age at smoking initiation, duration of smoking, current smoking at baseline and at first follow-up and smoke inhalation, occupational exposure to asbestos, as well as interactions between asbestos exposure and all smoking variables are introduced. This excess mortality is about 40% of the similar excess observed in the general male population of the same age. The education differences in lung cancer mortality observed in the ATBC Study reflect educational differences in lung cancer incidence; results from these data (not shown here) indicate that age-adjusted educational differences in lung cancer incidence are almost exactly the same as those observed for lung cancer mortality (RR 1.33 and 1.32, respectively).

The results of this study are in accordance with those showing that grade of employment differentials in lung cancer mortality persist even at a high level current smoking.[5] However, the excess observed in this study is relatively small in comparison to the about 2.5-fold excess mortality observed among heavy smoking men in the lowest grade. Our analyses have more accurately than any other study known to us adjusted for smoking by both restricting the analyses to a cohort of heavy smoking men and by adjusting for several aspects of smoking behaviour obtained from a questionnaire.

It is very unlikely that in the ATBC Study cohort the explanation for the excess mortality of basic-educated men can be largely attributed to residual confounding by exposure to tobacco smoke. The participants were men who smoked at baseline and had a very long smoking history. Furthermore, adjusting for survey information on smoking did not have any effect on the excess mortality of the basic educated. However, limitations of the survey questions on smoking and inaccurate response cannot be completely ruled out as potential explanations.

Other risk factors for lung cancer may partly account for the educational differences in lung cancer mortality if they are distributed unevenly by educational status. Of these, passive smoking seems to be of negligible relevance among heavy smokers.[4] Of other risk factors not related to tobacco smoke, two notable potential factors are occupational exposure to asbestos and other carcinogens, and exposure to indoor radon.[12–15] Both have been implicated in increased risk of lung cancer, although the findings concerning indoor radon are more limited.

However, exposure to radon is unlikely to be the explanation for education differences in lung cancer mortality. Firstly, recent estimates in Finland indicate that slightly more than 100 cases of lung cancer in men are annually related to radon exposure and that the majority of these cases appear in a synergistic relation with smoking. Only about one per cent of lung cancer could be avoided if exposure to radon were eliminated.[16] Furthermore, broad regional variations of indoor exposure to radon cannot easily be related to socioeconomic status. The great majority of individuals are unaware of the exposure and have thus been unable to take measures to protect themselves.

Altogether, workplace exposures (e.g. exposure to arsenic, polycyclic aromatic hydrocarbons, certain metal compounds, asbestos, radon) have been estimated to play an important role in causation of about 20% of lung cancer cases unrelated to smoking.[12] Exposure to these carcinogens has most likely been less for the better educated, fewer of whom work in affected jobs. Partial adjustment for asbestos exposure has been made with questionnaire information on asbestos mining, production and insulation. However, residual confounding is likely to exist because exposure to asbestos in the building and construction industry has not been fully reported. It has been estimated, that about 4% of lung cancer could have been avoided in the total Finnish male population if asbestos had not been used.[4] If this estimate were valid for the ATBC Study cohort, about 10 deaths could have been avoided. This is about 20% of all excess deaths among the basic educated. Also other occupational exposures, which together account for 13% of all lung cancers,[4] may have an important role in explaining excess lung cancer mortality among the basic educated.

In addition to risk factors, frequent consumption of fruit and vegetables may protect from lung cancer.[17] Socioeconomic differences in the consumption of these foodstuffs are well established in Finland.[18]

In summary, education differences in lung cancer mortality in a cohort of men with a long history of smoking are relatively small. This mortality difference is not necessarily the same as that operating at more modest levels of tobacco smoking or among non-smokers. However, because a large part of lung cancer deaths occur among regular and heavy smokers, the educational differences in lung cancer mortality in the total Finnish population are likely to mainly reflect the higher proportion of heavy smokers among the less educated people. Reduction of socioeconomic differences in smoking is likely to be the most efficient means of reducing socioeconomic differences in lung cancer mortality. Further understanding of the determinants of socioeconomic differences in smoking behaviour are thus of major scientific and public health importance.

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