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Incidence of cancer among the participants of the Finnish Asbestos Screening Campaign

by Koskinen K, Pukkala E, Reijula K, Karjalainen A

Affiliation: Uusimaa Regional Institute of Occupational Health, Helsinki, Finland. kari.koskinen@ttl.fi

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Key terms: asbestos; cancer; construction; Finnish Asbestos Screening Campaign; lung cancer; mesothelioma; shipyard

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Incidence of cancer among the participants of the Finnish Asbestos Screening Campaign

by Kari Koskinen, MD,[1] Eero Pukkala, PhD,[2] Kari Reijula MD,[1] Antti Karjalainen, MD[3]

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Objectives Cancer risk has been estimated for asbestos production workers or other heavily exposed asbestos workers in numerous studies. The bulk of the asbestos epidemic results come, however, from past intermittent exposures during asbestos product use. This study concentrated on estimating the risk of cancer in such a population.

Methods Altogether 23 285 men and 930 women invited to a nationwide screening campaign for benign asbestos-related diseases in 1990–1992 were followed for cancer through the Finnish Cancer Register up to 1998. Standardized incidence ratios (SIR) were calculated in comparison with the total Finnish population.

Results Altogether 1392 cases of cancer were found among the men. The risk was slightly, but significantly elevated for lung cancer [SIR 1.14, 95% confidence interval (95% CI) 1.01–1.26), mesothelioma (SIR 2.77, 95% CI 1.66–4.31), and prostate cancer (SIR 1.21, 95% CI 1.09–1.34). The risk of lung cancer was slightly higher among the invited nonparticipants (SIR 1.48, 95% CI 1.20–1.79) than among the participants (SIR 1.02, 95% CI 0.88–1.17). About 98% of the lung cancers occurred in current or ex-smokers.

Conclusions In a population of long-term construction workers, the risk of lung cancer and mesothelioma was increased, but considerably lower than among insulators, asbestos sprayers, or patients with asbestosis. As it was not possible to follow most of the invited nonparticipants in the original screening study, selection bias by smoking or other life-style factors possibly correlated to the individual's decision to participate in the health screening cannot be excluded.

Key terms asbestos, construction, lung cancer, mesothelioma, shipyard.

Altogether 300 000 tons of asbestos were used in Finland (population 5.2 million) between 1918 and 1988 for construction materials, ships, machines, transport vehicles, and various consumer products. The manufacture of asbestos products ceased in 1988, and since 1994 the use of asbestos has been totally banned. The annual use of raw asbestos was the highest in the 1960s and early 1970s (figure 1). The State Asbestos Committee estimated that, in the past several decades, over 200 000 workers had been exposed to asbestos, about 150 000 of them in the construction industry, 20 000 in shipyards, 20 000 in car repair shops, and 10 000 in the asbestos product industry (1).

Exposure to asbestos causes lung cancer, mesothelioma, pulmonary fibrosis (asbestosis), pleural plaques, and various other benign abnormalities of the pleura. The asbestos-associated risk of malignancies other than lung cancer and mesothelioma is less established. However, there are several reports of an elevated risk of laryngeal cancer (2–4), and some studies have also found an increased risk of cancer of the kidney and gastrointestinal tract (5, 6). Estimates of the current annual cancer burden due to past asbestos exposure in Finland range from 150 to more than 250 (7, 8). About 100 annual deaths due to asbestos-related cancer were compensated under the worker's compensation system in

1 Uusimaa Regional Institute of Occupational Health, Helsinki, Finland.
2 Finnish Cancer Registry, Helsinki, Finland.
3 Department of Epidemiology and Biostatistics, Finnish Institute of Occupational Health, Helsinki, Finland.

Reprint requests to: Dr Antti Karjalainen, Finnish Institute of Occupational Health, Topeliuksenkatu 41 a A, FIN-00250 Helsinki, Finland. [E-mail: antti.karjalainen@ttl.fi]

1995–2000 (Federation of Accident Insurance Institutions: http://www.vakes.fi/tvl/suomi).

In 1987–1992, the Finnish Institute of Occupational Health, together with various partners, carried out a national asbestos program aimed at minimizing asbestos exposure, identifying people exposed to asbestos, evaluating the health risk caused by asbestos, and improving the diagnosis of asbestos-induced diseases in Finland (7). A screening campaign was undertaken in 1990–1992 (9). It aimed (i) at identifying workers who had been subjected to long-term exposure to asbestos in construction, shipyard, or asbestos industry work, (ii) at detecting unrecognized asbestos-related occupational diseases among them, and (iii) at organizing their medical follow-up. The aim of the screening campaign was also to compile a register of exposed workers, which could be used in future occupational cancer evaluations of the participants and in future studies.

The annual cancer burden due to asbestos is heavy, and it has been estimated that it will increase (10). There is a societal need to organize an adequate health follow-up for those previously exposed, to provide balanced information on the magnitude of individual risk, and to ensure a justified and socially balanced compensation system for occupational diseases (11–13). Previous Finnish cohort studies and their recent updates have provided information on the level of cancer risk of anthophyllite miners (14), asbestos sprayers (15), and patients with asbestosis (2, 15, 16). These groups represent populations with a heavy past cumulative exposure to asbestos, while the bulk of the asbestos epidemic has resulted from exposure during the use of asbestos products in construction, shipyards, car repair, and industrial maintenance work, where the exposure was common, but usually not continuously heavy. The aim of our present study was to analyze the risk of cancer in a population representing such exposure.

Subjects and methods

The participants of the screening campaign in 1990–1992 were chosen from the Finnish occupational groups in which exposure to asbestos had been most common since the 1950s. The basic invitation criteria included an employment history of at least 10 years of employment in the construction industry (starting before 1980), 1 year of work in a shipyard (starting before 1976), or 1 year in the asbestos product industry (starting before 1981). Only persons under 70 years of age were included. They were selected from the registers of trade unions and pension funds (17). Persons matching the aforementioned inclusion criteria could not be directly identified from the registers. Therefore a preliminary questionnaire was sent to 54 409 workers who were considered possibly to fulfill the criteria, of whom 36 308 (67%) responded. Of these 10 062 did not want to participate, and 1657 were considered to have only low exposure. In addition, 629 persons (fulfilling the invitation criteria) spontaneously contacted the Finnish Institute of Occupational Health to express their willingness to participate. Altogether 24 589 persons were invited to the screening. Of these, 18 943 (77% of the invited) participated. In this follow-up study, we report the cancer incidence for all those who gave their permission for their health status to be followed (ie, 24 215 of the total 24 589 who had been invited). There were 23 285 men and 930 women (table 1). The mean year in which the participants entered the aforementioned risk occupation was 1960. At the time of the screening campaign, the mean duration of employment in the risk occupation was 26 years, and the subjects' mean age was 53 years.

The screening survey included a structured questionnaire interview carried out by a trained occupational health nurse. The questionnaire inquired about smoking

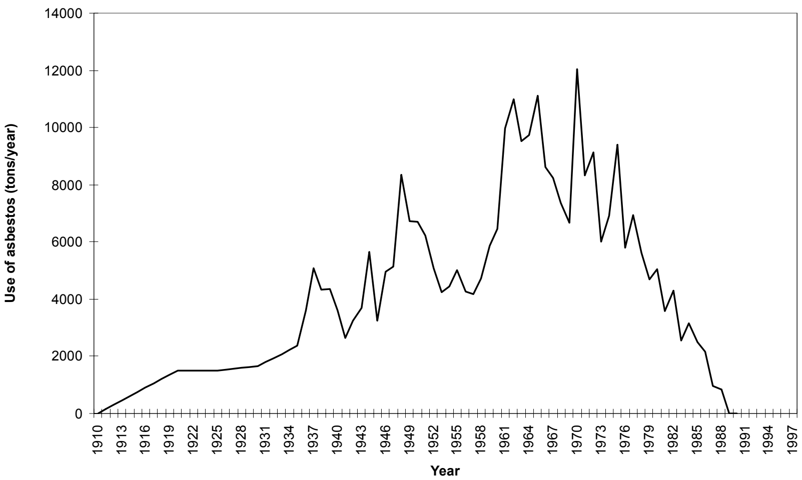

Figure 1. Use of raw asbestos in 1910–1990 in Finland, according to the statistics of the National Board of Customs, and the domestic use of Paakkila mine asbestos.

habits, and a complete job title and industrial sector history. A person was classified as a smoker if he or she had smoked at least one cigarette, cigar, or pipeful of tobacco per day for at least one year. Ex-smokers were persons who had stopped smoking at least 6 months before the screening visit. At the time of the interview, 28% of the men were current smokers, 42% were ex-smokers, and 30% were lifetime nonsmokers (table 2). Of the women, 24% were current smokers, 15% were ex-smokers, and 61% were never smokers. Smoking habits were known only for those who participated.

The follow-up for cancer was done through computer linkage with the Finnish Cancer Register, using the personal identifier as the key. The calculation of person-years started from the date of screening or from 1 January 1991 in the group of invited persons who did not participate. The calculation of person-years ended at emigration or death or on 1 December 1998, whichever occurred first. There were 167 889 person-years of follow-up for the men and 6693 for the women.

The numbers of cases of cancer and the person-years at risk were counted by 5-year age groups and two periods of follow-up (0–4 years and ≥5 years). The expected number of cases of cancer was calculated by multiplying the number of person-years in each stratum by the corresponding average cancer incidence in Finland. The standardized incidence ratio (SIR) was calculated by dividing the observed number of cases by the expected number of cases. The 95% confidence interval (95% CI) for the standardized incidence ratio was calculated from the Poisson distribution. There are no national cancer incidence rates available separately for smokers, ex-smokers, and nonsmokers. The results were similar for the two periods of follow-up (0–4 years and ≥5 years), and only the results for the entire follow-up period have been presented.

Table 1. Number of persons in the follow-up by gender, participation in the screening campaign, and industry.

Group	Men	Women	Total
Invited workers who participated	17 201	649	17 850
Construction industry	16 698	539	17 237
Shipyard	107	10	117
Asbestos industry	396	100	496
Participated via own contact	629	43	672
Invited but did not participate	5 455	238	5 693
All	23 285	930	24 215

Table 2. Distribution by age, gender, and smoking in the study population and the prevalence of smoking in the Finnish adult population in 1991–1993 (18).

	N	Smoking habits		
		Never smokers (%)	Ex-smokers (%)	Smokers (%)
Participants				
Men				
< 45 years	4253	34	30	36
45–59 years	8615	30	40	30
≥60 years	4962	25	56	19
All	17830	30	42	28
Women				
< 45 years	48	31	17	52
45–59 years	238	58	15	27
≥60 years	406	67	15	18
All	692	61	15	24
General population				
Men				
35–44 years	.	26	37	37
45–54 years	.	24	42	34
55–64 years	.	31	45	24
Women				
35–44 years	.	39	36	25
45–54 years	.	57	25	18
55–64 years	.	74	19	7

Results

Altogether 1392 cases of cancer were observed among the men during the follow-up. The standardized incidence ratio was significantly elevated for lung cancer, mesothelioma, and prostate cancer (table 3). Altogether 55 cases of cancer were observed among the women (table 3). There was some indication of an excess risk of cancers of the lung and cervix uteri, but these estimates were based on small numbers of observed cases and remained nonsignificant. There were no cases of mesothelioma among the women.

The standardized incidence ratio for lung cancer was higher among the nonparticipants (SIR 1.48, 95% Cl 1.20–1.79) than among the participants (SIR 1.02, 95% Cl 0.88–1.17) (table 4). It was slightly higher for adenocarcinoma and small-cell carcinoma of the lung than for squamous cell carcinoma or lung cancer with another or unknown histology.

The risk estimates of the total male cohort were greatly influenced by the construction worker subcohort, which constituted 72% of the total male cohort (table 4). The numbers of cases of cancer were small for the asbestos industry and shipyard workers, but there was an indication that these occupational groups had a higher risk of lung cancer and mesothelioma than those employed in the construction industry.

About 70% of the lung cancers and less than 10% of the mesotheliomas occurred in current smokers (table 5). The standardized incidence ratio for lung

Table 3. Observed number of cancer cases and the standardized incidence ratios (SIR) by cancer type for the Finnish men and women who were invited to the asbestos screening. (O = observed number, 95% CI = 95% confidence interval, exp = expected number of cases)

Cancer type	Men (N=23 285)			Women (N=930)		
	O	SIR	95% CI	O	SIR	95% CI
All sites	1 392	1.07	1.02–1.12	55	0.98	0.74– 1.27
Esophagus	11	0.63	0.31–1.12	–	exp 0.46	0.00– 7.97
Stomach	82	1.15	0.92–1.43	2	0.82	0.10– 2.96
Colon	67	1.00	0.77–1.26	3	0.84	0.17– 2.45
Rectum	60	1.05	0.80–1.34	1	0.46	0.01– 2.56
Pancreas	37	0.81	0.57–1.11	1	0.46	0.01– 2.55
Larynx	18	0.99	0.59–1.57	–	exp 0.09	0.00–39.1
Lung	302	1.14	1.01–1.26	7	2.39	0.96– 4.92
Adenocarcinoma	55	1.37	1.03–1.78	3	3.68	0.76–10.8
Squamous cell carcinoma	97	1.16	0.94–1.41	1	2.04	0.05–11.38
Small cell carcinoma	72	1.63	1.27–2.05	1	1.83	0.05–10.2
Other or no histology	78	0.80	0.63–1.00	2	1.87	0.23– 6.76
Mesothelioma	19	2.77	1.66–4.31	–	exp 0.13	0.00–29.2
Prostate	336	1.21	1.09–1.34	.	.	.
Breast	.	.	.	16	1.02	0.59– 1.66
Cervix uteri	.	.	.	3	4.24	0.87–12.4
Corpus uteri	.	.	.	4	0.88	0.24– 2.25
Ovary	.	.	.	2	0.60	0.07– 2.16
Kidney	65	1.06	0.82–1.35	2	0.98	0.12– 3.55
Bladder, ureter, urethra	77	0.98	0.77–1.21	1	0.91	0.02– 5.08
Non-Hodgkin lymphoma	47	0.93	0.68–1.23	3	1.36	0.28– 3.96

Table 4. Observed number of cases and standardized incidence ratios (SIR) for total cancer, laryngeal cancer, lung cancer, and mesothelioma according to industry and participation among the Finnish men invited to the asbestos screening. (O = observed number, 95% CI = 95% confidence interval, exp = expected number of cases)

Cancer type	Invited workers who participated									Participated via own contact (N=629)			Invited workers who did not participate (N=5455)		
	Construction (N=16698)			Shipyard (N=107)			Asbestos factory (N=396)								
	O	SIR	95%CI	O	SIR	95%CI	O	SIR	95%CI	O	SIR	95%CI	O	SIR	95%CI
All sites	944	1.01	0.95–1.08	10	1.17	0.56–2.15	18	1.25	0.74–1.97	21	1.14	0.71–1.74	399	1.22	1.10–1.33
Larynx	11	0.84	0.42–1.50	–	exp 0.11	0.00–34.1	–	exp 0.21	0.00–17.8	–	exp 0.30	0.00–12.4	7	1.57	0.63–3.23
Lung	192	1.01	0.87–1.15	4	2.20	0.60–5.63	5	1.77	0.57–4.12	2	0.59	0.07–2.12	99	1.48	1.20–1.79
Mesothelioma	12	2.43	1.26–4.24	–	exp 0.04	0.00–89.6	2	25.1	3.04–90.8	–	exp 0.11	0.00–32.7	5	2.93	0.95–6.84

Table 5. Observed number of cases and the standardized incidence ratios (SIR) for lung cancer and mesothelioma according to smoking habits among the male Finnish participants of the asbestos screening. (O = observed number, 95% CI = 95% confidence interval)

Cancer type	Smokers (N=5054)			Ex-smokers (N=7507)			Nonsmokers (N=5265)			Total (N=17826)		
	O	SIR	95% CI	O	SIR	95% CI	O	SIR	95% CI	O	SIR	95% CI
Lung	141	3.37	2.84–3.94	56	0.54	0.41–0.70	6	0.11	0.04–0.24	203	1.02	0.88–1.17
Mesothelioma	1	0.85	0.02–4.73	7	2.73	1.10–5.62	6	4.22	1.55–9.17	14	2.71	1.48–4.55

cancer among the current smokers was 30-fold, and for the ex-smokers it was 5-fold, that of the nonsmokers. Only one of the fourteen persons with mesothelioma and with known smoking habits was a current smoker (table 5).

Discussion

Our study series consisted mainly of construction workers. The risk of lung cancer in this group was only slightly increased. All the persons nevertheless had a long-term employment history in occupations with a high probability of past exposure to asbestos (ie, occupations which accounted for most of the use of all asbestos-containing products that were produced in the past). The cancer incidence was compared between the workers with a long employment history and the general population. Therefore we cannot exclude the healthy worker effect, which, however, in the case of cancer incidence is much smaller than in mortality studies and is restricted to the very first years of follow-up. The reference population also included numerous asbestos-exposed persons, an occurrence that also biased the observed risk estimates slightly downward.

The risk of lung cancer was higher for the invited workers who did not participate in the screening than for those who participated. It is probable that the decision to participate correlated with the person's general concern about his or her health. This finding could imply that those who participated had a healthier life-style and also higher motivation to protect themselves against work-related hazards. However, the prevalence of smokers among the participants of our study was similar to that in a random sample of the general population at the same point in time (table 2). A 1-year follow-up of a sample of the participants of the asbestos screening campaign showed that only 8% of the smoking participants had decided to quit smoking after the screening (19). Therefore, we conclude that the screening campaign itself did not affect smoking habits in such a way that would have biased our smoking category-specific results and that the prevalence of smoking was similar between our subjects and our reference population (ie, the general population of Finland). The similarity of the smoking habits between our subjects and the general population does not, however, exclude a possibility of some selection bias, since our subjects represented blue-collar workers and one would expect that their smoking prevalence would have been higher than that of the general population. It is also noteworthy that the slight increase in the risk of lung cancer was almost entirely due to the increased incidence among the 5455 who filled out the preliminary questionnaire but did not finally participate (table 4). On the other hand, those who participated via their own contact had a very low incidence of lung cancer, although based only on a few observed cases. All in all, it was highly indicated that a possible selection existed which could have caused bias through differences in smoking habits between those who participated and those who did not. The original selection of the study was based on union and pension registers, which, in Finland, are known to have good coverage of the workers employed in construction and the other risk trades. Yet the invitation to fill out the preliminary questionnaire had to be based on reasonably wide criteria in order to cover all those possibly fulfilling the final invitation criteria (see the Introduction). This procedure led to a low overall participation rate, which in turn left a possibility for important selection mechanisms. These mechanisms are difficult to verify afterwards, as it was not permitted to follow the invited persons who did not participate at all in the original screening study.

The incidence of mesothelioma is not related to smoking habits or other life-style factors. Therefore, problems related to selection bias were probably less important for mesothelioma than for lung cancer in our study. The observed risk of mesothelioma in our study group (SIR 2.8) also indicates a rather low exposure to asbestos in comparison with Finnish asbestos sprayers (SIR 260), anthophyllite miners (SIR 46), asbestosis patients (SIR 32), insulators (SIR 12), and patients with an occupational asbestos-related pleural disease (SIR 5.5) (2, 14, 15, 20). Yet most of the mesotheliomas among men in the general population are attributable to occupational exposure to asbestos, and the standardized incidence ratios, both in our study and in the other studies mentioned earlier, would have been considerably higher if the comparison had been made with a truly unexposed population. Such reference rates were not available. Our results indicate, however, that the average exposure to asbestos was relatively low in our study group. Therefore, the study does not allow conclusions to be drawn concerning asbestos-associated risks for cancers other than lung cancer or mesothelioma. The standardized incidence ratio for prostate cancer was slightly but significantly increased, but the role of asbestos remains open. The incidence of prostate cancer very much depends on the diagnostic activity (especially on the testing for prostate-specific antigen) and it may well be that those 67% of the men who were motivated to fill out the preliminary questionnaire of the asbestos screening campaign represent a population that also goes to their physician for routine health checks more than most men.

The distribution of the histological types of lung cancer differed between the study group and the general population. The incidence of adenocarcinoma and small-cell carcinoma among those who participated was significantly higher, and the incidence of lung cancer of unknown histology was lower than in the general population. These observations may reflect the fact that a specific diagnosis is more often reached if lung cancer occurs in a person with an already identified exposure history to asbestos. According to Finnish legislation, an autopsy is required in the case of death due to an established or suspected occupational disease. Therefore, at least for peripheral lung adenocarcinomas, a specific histological diagnosis may more often be reached for those who have an identified history of asbestos exposure.

A multiplicative interaction is believed to occur between asbestos and smoking in the causation of lung cancer (21). Our results clearly demonstrate the public health impact of this interaction, as opposed to asbestos exposure alone. About 70% of the lung cancers occurred among those currently smoking at the time of the screening campaign, and 28% occurred among the ex-smokers. The modifying effect of smoking, as well as the magnitude of the asbestos-associated risk, should also be taken into account when workers in construction and related industries are provided with information about their individual risk. Our results indicate that there is a risk of undue fear if such quantitative information is based on risk estimates from previous studies in heavily exposed cohorts.

We observed 37 excess cases of lung cancer and 12 excess cases of mesothelioma during the 168 000 person-years of follow-up among the men. If applied to the estimate of 200 000 persons with past occupational asbestos exposure in Finland, these rates correspond to about 60 annual asbestos-related cancers. As the average age of our study population may be younger than that of the total exposed population, we may have underestimated the cancer burden from exposures in the 1940s and 1950s. Furthermore, our study population did not include those small heavily asbestos-exposed groups that, at the time of the initial screening campaign, were already under medical surveillance due to their past exposure (eg, asbestos sprayers, anthophyllite miners, patients diagnosed with asbestosis). Hence the estimates of 150 to 200 annual asbestos-related cancers in Finland (7, 8) seem to be of the correct order of magnitude. These figures correspond to 8–10% of all lung cancers diagnosed annually in Finland. Previous Nordic studies have estimated the population attributable fraction of asbestos exposure in lung cancer among men to be 19% in the greater Helsinki area (22), 23% in Telemark (23), and 16% in Göteborg (24). These are all highly industrialized areas and the population attributable fraction has been estimated to be 14% and 0.6% for lung cancer among men and women, respectively, in Finland overall (8) and 5% for lung cancer among men in the Nordic countries overall (25). In the Helsinki area, construction work was reported as the main source of exposure, while, in Göteborg, insulation work and shipyard work and, in Telemark, maintenance work were the most commonly reported exposures. In our study, the risk of lung cancer was not increased among the construction workers, while there was some increase in risk among the shipyard workers and asbestos industry workers, as well as among those who did not participate in the screening study. Construction workers are a heterogeneous group, and the risk of lung cancer is mainly influenced by smoking habits. Yet our results indicate that a screening study focusing on construction workers may have missed the most important risk groups.

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