

Cancer incidence of workers in the Finnish pulp and paper industry

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JÄPPINEN P, HAKULINEN T, PUKKALA E, TOLA S, KURPPA K. Cancer incidence of workers in the Finnish pulp and paper industry. *Scand J Work Environ Health* 13 (1987) 197–202. The cancer incidence of 3 545 workers in the Finnish pulp and paper industry was assessed in a retrospective cohort study. The cohort included workers with continuous employment of at least one year between 1 January 1945 and 31 December 1961 and was followed until 31 December 1980. Six subcohorts were formed (sulfite mill, sulfate mill, paper mill, board mill, maintenance department, and power plant). Separate analyses were made for the 2 597 workers hired after 1 January 1945. The smoking habits were surveyed. Among the men, 196 cases of primary cancer were detected versus 203.8 expected [standardized incidence ratio (SIR) 96, 95 % confidence interval (95 % CI) 82–114], and there were 47 cancer cases among the women versus 57.9 expected (SIR 91, 95 % CI 60–108). Lung cancer occurred in 78 men (62.6 expected, SIR 125, 95 % CI 98–155), and the excess was the most prominent for the male board mill workers (40 observed, 18.1 expected, SIR 222, 95 % CI 158–302), particularly after 20 years' latency (25 observed, 7.8 expected, SIR 323, 95 % CI 209–476). Analogous excesses of lung cancer occurred among the men (especially the male board mill workers) who began work after 1 January 1945. The findings were not explained by smoking habits.

Key terms: cohort study, lung cancer.

In 1985, there were 38 300 blue-collar workers and 9 970 white-collar workers employed in the Finnish pulp and paper industry. Together, these numbers correspond to 2 % of the economically active population of 2.4 million.

Some potential human carcinogens have occurred in the pulp and paper industry, such as asbestos, auramine, and chlorinated phenols. The epidemiologic data presently available are not adequate enough however for an evaluation of the cancer risk in this industry (10). An increased risk of neoplasms of the lymphatic system has been reported (7, 8, 15, 16, 18, 21), as well as excesses of other malignancies, especially lung cancer (1, 9, 14). There are, however, inconsistencies between different studies.

The aim of the present study was to assess the cancer incidence among workers of the Finnish pulp and paper industry.

Subjects and methods

The study cohort was formed of workers in three pulp and paper mills in the province of Kymi in southeastern

Finland. One of the mills, in operation from 1910 to 1962, had employed the acidic or sulfite pulping process. The other two, still in operation, use the alkaline or sulfate pulping process.

The workers were grouped into the following six subcohorts according to the work area: (i) sulfite mill, (ii) sulfate mill, (iii) paper mill, (iv) board mill, (v) maintenance department, and (vi) power plant. The six subcohorts are separate entities with characteristic exposures within the industry (10, 11, 21). There were slight modifications in the processes, but basically pulp, paper and board were produced in the same way through the whole study period.

There have been only small differences in the cancer incidence between the province of Kymi (344 300 inhabitants in 1980, 15 % of the population of Finland) and the whole of Finland. In the present study, the incidence figures for the population of Kymi have been used as reference. The figures were essentially similar when the expected numbers of cancers were calculated with the use of the national incidence rates (data not shown).

The study population (table 1) consisted of all the workers who had been working continuously at one or more of the three mills for at least one year during the study period (1 January 1945 to 31 December 1961). A worker could be included in more than one subcohort. Workers who had not been exposed to actual process conditions were not included in the study. At the beginning of the study period (1 January 1945), 728 men and 220 women were already employed and working for the company.

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Table 1. Years of follow-up of the total cohort and subcohorts by sex.

	Men		Women	
	Number of workers	Follow-up (years)	Number of workers	Follow-up (years)
Total cohort	2 696	59 021	849	19 899
Subcohorts				
Sulfite mill	248	5 337	109	2 661
Sulfate mill	715	15 055	306	6 965
Paper mill	233	4 926	249	6 039
Board mill	823	16 682	271	5 407
Maintenance department	1 303	27 918	117	2 416
Power plant	486	9 648	45	871

The basic source of employment data was the company employment files, where all changes of job or foreman for each of approximately 50 000 persons were recorded. These permanent files were complete, and their completeness was insured by a check of the material against separately kept employer statistics of the mills.

The subcohorts were formed with special emphasis on adequate work histories. As the work histories were accurate, it was possible to exclude all of those persons from the study population who had worked, even occasionally, outside their regular work environment during the minimum exposure period.

The personal data, including follow-up until death or the end of 1981, were confirmed in the National Population Register, and, when necessary, in local population registers. Retirement or change of job did not affect the follow-up. The cause of death was retrieved through the Central Statistical Office. Information was also obtained from Statistics Sweden and from the authorities of Norway, Denmark, Canada, and Australia.

All members of the cohort were identified. The follow-up was complete for all those who were still living or had died in Finland and for most of those who had emigrated. In all, 13 workers (0.4 %) were lost in the follow-up. They had all emigrated from Finland to places with inadequate registries.

The cancer incidence was followed from 1 January 1953 until 31 December 1980, through the use of the data of the Finnish Cancer Registry, which has virtually complete data on all primary cancers notified in Finland since 1953, with histological types (22). There has been emigration from Finland to Sweden, and also to Norway in recent years. Information on the primary cancers of the emigrated workers was also obtained from the population-based cancer registers of Sweden and Norway. Therefore, it could be assumed that the cancer data for the cohorts were practically complete. Some persons who had moved to countries where adequate cancer registers were not available were contacted for information on possible malignancies. If no information was obtained on the possible primary cancers of an emigrated person known to be still alive, the date of emigration was used as the end point of the follow-up.

The person-years were accounted for from the end of the minimum exposure period (one year) until death, the closing date of the follow-up, or (for the 13 lost cases in the follow-up and for those living emigrants for whom there was no information on primary cancers) until the date of emigration. No data were available on possible work periods in pulp and paper mills owned by other companies, but a change of employer has been rare within the industry.

The expected numbers of primary cancers were calculated by five-year age groups, ten-year calendar periods, and five-year latency (time since first employment in the specific work area) periods. The age, gender, and calendar-period-specific numbers of person-years at risk in each subcohort were multiplied by the corresponding cancer incidence rates. Standardized incidence ratios (SIR) were obtained as ratios between the observed and expected numbers of cases. Ninety-five percent confidence intervals (95 % CI) were estimated on the assumption of a Poisson distribution for the observed number of cases. According to the duration of employment, separate analyses were made for two categories (1—4 years and ≥ 5 years). Separate analyses were also made for the 2 597 workers (1 968 men and 629 women) who were employed for the first time after 1 January 1945.

The smoking habits of a stratified random sample (4) of the study population were inquired about. The workers in each group were listed in alphabetical order, without separation for gender or vital status, and a statistically representative sample was selected. A total of 801 questionnaires were sent, 264 of them to relatives of deceased workers. A reply was received from 82.8 % of the sample.

Results

In the whole pulp and paper cohort, the observed number ($N = 196$) of all primary cancers among the men did not differ markedly from that expected ($N = 203.8$) (table 2). However, there were 78 observed malignancies of the trachea, bronchi, lungs and pleura (subsequently denoted as "lung") among the men versus 62.6 expected. There were no mesotheliomas among the histological types of these malignancies. With a latency of 25 years or more, there were 50 lung cancers among the men versus 36.2 expected (SIR 138, 95 % CI 103—182). Men with an occupational exposure of five years or more had 65 lung cancers versus 54.5 expected (SIR 119, 95 % CI 92—152).

There were 86 primary cancers versus 106.4 expected (SIR 81, 95 % CI 65—100) among the men employed after 1 January 1945. Thirty-eight of them were lung cancers, versus 31.4 expected (SIR 121, 95 % CI 86—166). With a latency of 25 years or more, there were 14 lung cancers among these men versus 10.0 expected (SIR 140, 95 % CI 77—235).

In the sulfate mill subcohort (table 3), there was an elevated number of genital cancers among the men (9

observed, 4.8 expected), whereas there were no marked differences in cancer incidence in the sulfite mill subcohort. In the paper mill subcohort, the men showed an excess of lung cancer (12 observed, 6.1 expected). This excess was also obvious among the men with an occupational exposure of five years or more (10 observed, 4.9 expected, SIR 205, 95 % CI 98–377).

Among the board mill workers (table 4), there was a marked excess of lung cancer among the men (40 observed, 18.1 expected). In this subcohort men with an occupational exposure of five years or more had a greater difference between the observed and expected numbers of lung cancer than those with an exposure of one to four years (table 5). The risk of lung cancer

Table 2. The observed (O) and expected (E) numbers of all primary cancers and of cancers in selected sites of workers in the pulp and paper industry and the corresponding standardized incidence ratios (SIR) with 95 % confidence intervals (95 % CI) by sex. The population of the province of Kymi has been used as reference.

Site ^a	Men				Women			
	O	E	SIR ^b	95 % CI ^b	O	E	SIR ^b	95 % CI ^b
All cancers (140–209)	196	203.8	96	82–114	47	57.9	81	60–108
Lip, mouth and pharynx (140–148)	5	8.7	57	19–134	—	1.1	..	..
Digestive organs (150–159)	47	60.9	77	57–103	11	16.7	66	33–118
Stomach (151)	24	28.8	83	53–124	5	6.2	80	26–187
Colon (153)	8	7.2	111	48–218	1	2.9	..	..
Rectum (154)	2	7.6	..	..	1	2.3	..	..
Larynx (161)	5	5.7	88	29–206	—	0.1	..	..
Trachea, bronchi, lungs and pleura (162–163)	78	62.6	125	98–155	1	1.6	..	..
Skin (173) ^c	3	4.7	64	13–188	1	1.4	..	..
Breast (174)	—	0.1	..	..	8	12.5	64	28–126
Genital organs (180–187)	17	17.2	99	58–159	13	12.5	104	55–178
Bladder (188)	11	6.9	159	79–285	—	0.5	..	..
Lymphoma (200–202)	3	5.9	51	11–149	1	1.4	..	..
Hodgkin's disease (201)	1	2.4	..	..	1	0.4	..	..
Leukemia (204–207)	4	5.0	80	22–204	1	1.4	..	..

^a Code of the International Classification of Diseases, eighth revision, in parentheses.

^b SIR and 95 % CI not calculated when the number of observed cases (O) was <3.

^c Not including melanomas.

Table 3. The observed (O) and expected (E) numbers of all primary cancers and of cancers in selected sites of the men employed in the sulfite mill, the sulfate mill, and the paper mill and the corresponding standardized incidence ratios (SIR) with 95 % confidence intervals (95 % CI). The population of the province of Kymi has been used as reference.

Site ^a	Sulfite mill				Sulfate mill				Paper mill			
	O	E	SIR ^b	95 % CI ^b	O	E	SIR ^b	95 % CI ^b	O	E	SIR ^b	95 % CI ^b
All cancers (140–209)	33	31.4	105	72–147	54	58.7	92	69–120	24	19.8	121	78–181
Lip, mouth and pharynx (140–148)	1	1.3	..	..	2	2.5	..	..	1	0.8	..	..
Digestive organs (150–159)	9	9.7	93	43–177	14	17.3	81	44–136	8	6.1	132	57–259
Stomach (151)	6	4.6	129	47–281	7	8.1	87	35–179	5	2.9	171	55–398
Colon (153)	1	1.1	..	..	4	2.1	192	52–492	—	0.7	..	..
Rectum (154)	—	1.2	..	..	—	2.2	..	..	—	0.7	..	..
Larynx (161)	1	0.8	..	..	—	1.7	..	..	—	0.5	..	..
Trachea, bronchi, lungs and pleura (162–163)	9	10.0	90	41–171	16	18.5	87	49–141	12	6.1	197	102–345
Skin (173) ^c	1	0.7	..	..	2	1.3	..	..	—	0.5	..	..
Genital organs (185–187)	4	2.9	137	37–350	9	4.8	186	85–354	1	1.8	..	..
Bladder (188)	3	1.1	270	56–790	3	2.0	149	31–434	—	0.7	..	..
Lymphoma (200–202)	—	0.7	..	..	—	1.6	..	..	—	0.5	..	..
Hodgkin's disease (201)	—	0.3	..	..	—	0.6	..	..	—	0.2	..	..
Leukemia (204–207)	1	0.7	..	..	—	1.4	..	..	1	0.5	..	..

^a Code of the International Classification of Diseases, eighth revision, in parentheses.

^b SIR and 95 % CI not calculated when the number of observed cases (O) was <3.

^c Not including melanomas.

Table 4. The observed (O) and expected (E) numbers of all primary cancers and of cancers in selected sites of the men employed in the board mill, the maintenance department, and the power plant and the corresponding standardized incidence ratios (SIR) with 95 % confidence intervals (95 % CI). The population of the province of Kymi has been used as reference.

Site ^a	Board mill				Maintenance department				Power plant			
	O	E	SIR ^b	95 % CI ^b	O	E	SIR ^b	95 % CI ^b	O	E	SIR ^b	95 % CI ^b
All cancers (140–209)	65	58.5	111	86–142	99	109.2	91	74–110	28	32.5	86	57–125
Lip, mouth and pharynx (140–148)	—	2.4	..	..	1	4.6	..	..	1	1.4	..	..
Digestive organs (150–159)	12	17.3	70	36–121	17	32.8	52	30–83	11	9.5	116	58–208
Stomach (151)	5	8.0	62	20–145	5	15.5	32	10–75	9	4.4	207	95–393
Colon (153)	5	2.1	239	78–558	3	3.9	78	16–228	—	1.2	..	..
Rectum (154)	1	2.2	..	..	2	4.1	..	..	—	1.2	..	..
Larynx (161)	—	1.6	..	..	2	3.0	..	..	3	0.9	319	66–933
Trachea, bronchi, lungs and pleura (162–163)	40	18.1	222	158–302	43	34.0	127	92–170	5	10.1	50	16–116
Skin (173) ^c	—	1.3	..	..	2	2.5	..	..	—	0.7	..	..
Genital organs (185–187)	2	5.2	..	..	11	9.6	115	58–206	3	2.7	113	23–331
Bladder (188)	3	2.0	148	30–432	4	3.8	106	29–272	1	1.1	..	..
Lymphoma (200–202)	1	1.7	..	..	3	3.0	101	21–295	—	1.0	..	..
Hodgkin's disease (201)	—	0.7	..	..	1	1.2	..	..	—	0.4	..	..
Leukemia (204–207)	—	1.4	..	..	4	2.6	154	42–394	—	0.8	..	..

^a Code of the International Classification of Diseases, eighth revision, in parentheses.

^b SIR and 95 % CI not calculated when the number of observed cases (O) was <3.

^c Not including melanomas.

Table 5. The observed (O) and expected (E) numbers of lung cancer among the men employed in the board mill and the corresponding standardized incidence ratios (SIR) with 95 % confidence intervals (95 % CI) by latency (time since first employment) and duration of employment.

Latency (years)	Duration of employment											
	1–4 years				≥5 years				Total			
	O	E	SIR ^a	95 % CI ^a	O	E	SIR ^a	95 % CI ^a	O	E	SIR ^a	95 % CI ^a
≤4	2	1.3	..	..	..	..	..	..	2	1.3	..	..
5–9	2	1.6	..	..	1	0.8	..	..	3	2.5	122	25–356
10–14	2	2.0	..	..	3	1.2	254	52–743	5	3.2	155	50–362
15–19	2	2.4	..	..	3	1.0	306	63–895	5	3.3	150	49–349
20–24	10	2.7	377	181–694	2	0.8	..	..	12	3.5	345	178–602
≥25	7	3.1	224	90–462	6	1.2	522	191–1136	13	4.3	304	162–521
Total	25	13.1	191	124–282	15	5.0	301	169–497	40	18.1	222	158–302

^a SIR and 95 % CI not calculated when the number of observed cases (O) was <3.

Table 6. The observed (O) and expected (E) numbers of all primary cancers in the women of the pulp and paper subcohorts and the corresponding standardized incidence ratios (SIR) with 95 % confidence intervals (95 % CI). The population of the province of Kymi has been used as reference.

Subcohort	O	E	SIR ^a	95 % CI ^a
Sulfite mill	7	9.8	72	29–148
Sulfate mill	15	22.4	67	38–111
Paper mill	20	20.9	96	58–148
Board mill	9	10.5	86	39–163
Maintenance department	8	8.8	91	39–179
Power plant	2	3.4	..	..

^a SIR and 95 % CI not calculated when the number of observed cases (O) was <3.

increased with follow-up time, 25 of the 40 cases having occurred after 20 years or more since first employment, versus 7.8 expected (table 5).

There were 37 lung cancers among the male board mill workers employed after 1 January 1945 versus 17.0 expected (SIR 218, 95 % CI 153–300). Twenty-two of these cancers occurred after 20 years or more since first employment versus 6.8 expected. Among the men employed after 1 January 1945 and with an occupational exposure of five years or more, there were 12 lung cancers versus 4.8 expected (SIR 248, 95 % CI 128–433).

In the maintenance department subcohort (table 4), there were deficits of stomach cancer, and also of cancers of the digestive organs as a whole, among the men. Men with an occupational exposure of five years or more had 13 observed cancers in the digestive organs versus 23.8 expected (SIR 55, 95 % CI 29–94). Four had stomach cancer (11.2 expected, SIR 36, 95 % CI 10–91). In this same subcohort there were 43 cases

of lung cancer among the men versus 34.0 expected. There was an analogous deficit of cancers of the digestive organs among those men employed after 1 January 1945 (10 observed, 19.4 expected, SIR 51, 95 % CI 25–95).

In the power plant subcohort, there were no marked cancer excesses or deficits.

Except for lung cancer, there were no marked increases or decreases in cancer risk related to the length of occupational exposure or latency in any subcohort. The same applied to the workers employed after 1 January 1945.

The observed numbers of all cancers among the women were slightly less than those expected in all the subcohorts (table 6).

The prevalence of smoking in 1956 did not vary markedly among the men between most of the subcohorts (from 46.8 % in the maintenance department to 61.9 % in the paper mill), although it was considerably high (80.0 %) in the sulfate mill subcohort. The results of the questionnaire study on smoking have been presented in a separate paper (12).

Discussion

The results of the present study showed an excess of lung cancer among the men of a Finnish pulp and paper cohort, especially among the male board mill workers. The excess was more pronounced for the men with an exposure of five years or more, and it increased with increasing latency. There were analogous excesses of lung cancer among the men, especially those of the board mill subcohort, who were employed for the first time after 1 January 1945.

In some earlier studies there have been findings indicating an increased risk of lung cancer within the paper industry (1, 9, 14, 23), although there are also studies showing no excess, or insignificant excesses, of lung cancer (6, 17, 21).

In several studies on cancer and industrial exposures, smoking has been a confounding factor. In the present study, the prevalence of smoking for the men in 1956 was lower than presented earlier for the general population (13), except among the sulfate mill subcohort. The prevalence of smoking for the men in 1981 was of the same magnitude as the figures reported earlier for the years 1976 (20) and 1977 (19). Therefore, the excess of lung cancer among the men of the whole study cohort and among the board mill subcohort is not likely to be explained by differences in smoking habits.

Some European brands of talc have contained small amounts of asbestos as an impurity, but these brands have not been in use in the mills under study. The brakeshoes of the slitting machines contained asbestos until the late 1970s. Machine clothing that contained asbestos, as well as asbestos gloves, were used earlier in the paper and board mills. In addition to asbestos, some other potential carcinogens were used in the

board mills in the 1950s and, especially, the 1960s, eg, dyes (such as auramine) and chlorinated phenols. Whether the excess of lung cancer can be attributed to carcinogenic exposures within the workplace is by no means clear, and more detailed studies seem warranted.

There are no clear explanations for the deficits of cancers of the digestive organs and stomach among the workers in the maintenance department. Teppo et al (23) found that, in the Finnish population, stomach cancer is rare in the higher social classes. The standard of living of the workers in the pulp and paper industry has been increasing since the early 1950s, but there is no obvious reason for a difference between the maintenance department and the other subcohorts in that respect. It should be noted that recently Robinson et al (21) found an excess risk of stomach cancer among sulfite pulp mill workers in their mortality study. Milham & Demers (17) also found an excess of stomach cancer among pulp and paper workers in their proportionate mortality study.

The results of the present study did not show an elevated risk of laryngeal cancer or cancer of the lip, mouth and pharynx region in the total study cohort or in any of its subcohorts. This result was in accordance with those of Robinson et al (21). An increased risk for oral, pharyngeal, and laryngeal cancer has been previously reported among male paper workers (2, 3, 5).

There have been reports (7, 8, 15, 16, 18) of an increased risk of Hodgkin's disease in the pulp and paper industry, as well as of an increased risk of lymphosarcoma and reticulosarcoma among sulfite pulp mill workers (21). In the present study, there was no excess of lymphomas. In a proportionate mortality analysis, a slight excess of leukemia was found for pulp and paper workers in Washington State (14). In the present study, there was no marked excess of leukemia.

In conclusion, no excess risk of primary cancer in general was observed among the pulp and paper workers of our study, whereas an excess of lung cancer was found, especially among the male board mill workers and particularly when duration of employment and latency period were taken into account. The excess was not explained by smoking habits.

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