

## Cancer incidence of workers in a Finnish sawmill

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JÄPPINEN P, PUKKALA E, TOLA S. Cancer incidence of workers in a Finnish sawmill. *Scand J Work Environ Health* 1989;15:18–23. The cancer incidence of 1 223 sawmill workers with continuous employment of at least one year between 1 January 1945 and 31 December 1961 was followed until 31 December 1980. Separate analyses were made for the 801 workers hired after 1 January 1945, and smoking habits were surveyed. Among the men, 90 cases of primary cancer were detected versus 83.5 expected and among the women 55 cancer cases versus 44.5 expected. Skin cancer was in excess among the men, especially among those employed after 1 January 1945. Lip, mouth, and pharynx cancer and lymphomas were also slightly in excess among the men, as was leukemia among both sexes. Workplace exposure, especially to chlorophenols, may be associated with the excess skin cancer and the slight excess of lymphomas, but this finding should be further evaluated with special emphasis on well-defined exposure data.

**Key terms:** chlorophenols, cohort study, sawmill workers, skin cancer.

There are limited data on the incidence of cancer among sawmill workers, despite the importance of the sawmill industry in many countries. For instance, in Finland there were 17 375 workers employed by the sawmill industry in 1985 (1), ie, 0.8 % of the active working population. In addition, in many epidemiologic studies lumber and sawmill workers have been combined, and thus interpreting the results with respect to sawmill workers alone is difficult (2). Furthermore, the epidemiologic data are mainly from surveys of occupations on death certificates (2).

Sawmill workers are exposed mainly to wood dust, antistain agents, sawing vapors, and fungal spores. In addition, many other types of compounds with possible health effects can be found in smaller amounts in their work environment (2).

Various types of cancer excess have been reported for sawmill workers. For example, there have been reports of an increased risk for nasal cancer (3, 4). Nasal adenocarcinomas have been reported to be associated with hardwood dust exposure, but not with the softwood dust exposure typical in Finnish sawmills (5). However, there is a report of an association between other types of nasal and sinus paranasal cancer and exposure to softwoods (6). Although one death certificate study showed an increased risk of lung cancer among sawmill workers (7), there are other studies showing no excesses of lung cancer (8, 9) among these workers. There are reports of increased risk for Hodgkin's disease (10) and for leukemia and lympho-

ma (9) among sawmill workers. Increased risks of soft-tissue sarcomas and histiocytic lymphomas have been associated with chlorophenol exposure, which also takes place in the sawmill industry (11–13).

The aim of the present study was to assess the incidence of cancer among workers of a Finnish sawmill. The investigation was performed simultaneously with a study of cancer incidence among Finnish pulp and paper workers (14).

### Subjects and methods

The study cohort was formed from workers in a sawmill in the province of Kymi in southeastern Finland. The frame sawmill, founded in 1872, has an annual capacity of 100 000 m<sup>3</sup> of sawn timber (80 % pine, 20 % spruce). During the 1950s and 1960s the number of workers was over 400, but, as a result of modernization in 1974, the sawmill now employs only 144 persons. Chlorophenols were used as antistain agents in this sawmill from 1945 to 1983. Sawn timber was submerged in a 0.5 % aqueous chlorophenol solution for approximately 1 min during the warm season. The commercial chlorophenol product has contained sodium salt of pentachlorophenol (5–9 % by weight), sodium salt of 2,3,4,6-tetrachlorophenol (78–83 %), and 2,4,6-trichlorophenol (7–15 %) (15).

The study population (721 men and 502 women, for a total of 1 223 workers) consisted of all the workers who had been employed continuously at the sawmill for at least one year during the study period (1 January 1945 to 31 December 1961). At the beginning of the study period (1 January 1945), 304 men and 198 women of the cohort were already employed in the sawmill.

The basic source of employment data was the company employment files. Their completeness was en-

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sured by a check of the material against separately kept employer statistics of the mills. No data were available on possible work periods in other sawmills, but a change of employer has been rather rare.

The personal data, including follow-up until death or the end of 1981, were confirmed in the National Population Register, and in local population registers when necessary. 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 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. Only three workers (0.2 %) were lost. They had all emigrated from Finland to places with inadequate registers.

The cancer incidence was followed from 1 January 1953 until 31 December 1980 through the use of the data of the Finnish Cancer Registry. It has virtually complete data on all primary cancers, and their histological types, notified in Finland since 1953 (16). Since there has been emigration from Finland to Sweden and to a less extent to Norway, information on the primary cancers of the emigrated workers was also obtained from the population-based cancer registers of these countries. It could thus be assumed that the cancer data were practically complete. 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 (table 1) were calculated from the end of the minimum exposure period (one year) until death, the closing date of the follow-up, or (for the three 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.

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) periods. The age, gender, and calendar-period specific numbers of person-years at risk were multiplied by the corresponding cancer incidence rates. The incidence figures for the population of Kymi were used as reference. The standardized incidence ratios (SIR) were obtained as ratios between the observed and expected numbers of cases. The 95 % confidence intervals (95 % CI) were estimated on the assumption of a Poisson distribution for the observed number of cases. Separate analyses were made for two categories according to the duration of employment (1–4 years and  $\geq 5$  years). Furthermore, separate analyses were made for the workers who were employed for the first time after 1 January 1945 in order that a cohort with adequately defined exposure data would be available, especially in the case of chlorophenols.

The smoking habits of a random sample of the study population were assessed. The workers were listed in

alphabetical order, without separation for gender or vital status, and a random sample was selected. A total of 144 questionnaires were sent. A reply was received from 74.3 % of the sample.

## Results

The observed number of all primary cancers (table 2) among the men was somewhat higher than that expected (90 observed, 83.5 expected, SIR 108, 95 % CI 87–133). Among the women, there was also an excess of all primary cancers (55 observed, 44.5 expected, SIR 124, 95 % CI 93–161).

There was an excess of skin cancer among the men (6 observed, 1.9 expected, SIR 313, 95 % CI 115–680). The risk of skin cancer among the men did not differ between the groups with an occupational exposure of less than five years and at least five years, but the risk increased with follow-up time so that five of the six cases occurred after 15 years or more since first employment (versus 1.7 expected). The occupational histories of the subjects with skin cancer are presented in table 3.

Cancer of the lip, mouth, and pharynx was in excess among the men (6 observed, 3.4 expected, SIR 175, 95 % CI 64–382). All six cases occurred after 25 years or more since first employment.

Colon cancer was also in excess among the men (5 observed, 2.9 expected, SIR 174, 95 % CI 56–405), as was rectal cancer among the women (4 observed, 1.8 expected, SIR 226, 95 % CI 62–579).

There were also excesses of all lymphomas, especially Hodgkin's disease, among the men, and an excess of leukemia among both sexes. The numbers of the observed and expected cases were low however (table 2). The risk of lymphomas among the men was somewhat higher for those with an occupational exposure of at least five years (4 observed, 1.5 expected, SIR 268, 95 % CI 73–687). The job titles and major occupational exposures of the subjects with lymphoma or leukemia are presented in table 3.

The women had four cases of lung cancer versus 1.2 expected (SIR 325, 95 % CI 89–833), but the number of lung cancer cases among the men was almost the same as that expected (table 2).

**Table 1.** Number of workers and follow-up years by sex and date of first employment.

| Sex                        | Workers employed for the first time after 1 January 1945 |                   | Total cohort      |                   |
|----------------------------|----------------------------------------------------------|-------------------|-------------------|-------------------|
|                            | Number of workers                                        | Follow-up (years) | Number of workers | Follow-up (years) |
| Male                       | 417                                                      | 9 552             | 721               | 15 962            |
| Female                     | 384                                                      | 7 643             | 502               | 12 684            |
| Males and females combined | 801                                                      | 17 195            | 1 223             | 28 646            |

**Table 2.** Observed (O) and expected (E) numbers of all primary cancers and of cancers in selected sites of sawmill workers 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 <sup>a</sup>                            | Men |      |                  |                      | Women |      |                  |                      |
|----------------------------------------------|-----|------|------------------|----------------------|-------|------|------------------|----------------------|
|                                              | O   | E    | SIR <sup>b</sup> | 95 % CI <sup>b</sup> | O     | E    | SIR <sup>b</sup> | 95 % CI <sup>b</sup> |
| All cancers (140—209)                        | 90  | 83.5 | 108              | 87—133               | 55    | 44.5 | 124              | 93—161               |
| Lip, mouth and pharynx (140—148)             | 6   | 3.4  | 175              | 64—382               | 1     | 0.9  | ..               | ..                   |
| Digestive organs (150—159)                   | 24  | 26.6 | 90               | 58—134               | 18    | 12.7 | 141              | 84—223               |
| Stomach (151)                                | 11  | 13.1 | 84               | 42—150               | 5     | 4.7  | 107              | 35—249               |
| Colon (153)                                  | 5   | 2.9  | 174              | 56—405               | 2     | 2.3  | ..               | ..                   |
| Rectum (154)                                 | 4   | 3.1  | 128              | 35—327               | 4     | 1.8  | 226              | 62—579               |
| Nose (160) <sup>c</sup>                      | —   | 0.2  | ..               | ..                   | —     | 0.1  | ..               | ..                   |
| Larynx (161)                                 | 2   | 2.1  | ..               | ..                   | —     | 0.1  | ..               | ..                   |
| Trachea, bronchi, lungs and pleura (162—163) | 24  | 25.4 | 95               | 61—141               | 4     | 1.2  | 325              | 89—833               |
| Soft-tissue sarcoma (171)                    | —   | 0.4  | ..               | ..                   | 1     | 0.2  | ..               | ..                   |
| Skin (173) <sup>d</sup>                      | 6   | 1.9  | 313              | 115—680              | 2     | 1.1  | ..               | ..                   |
| Breast (174)                                 | —   | 0.1  | ..               | ..                   | 8     | 9.5  | 84               | 36—166               |
| Genital organs (180—187)                     | 9   | 7.9  | 114              | 52—216               | 9     | 10.0 | 90               | 41—171               |
| Bladder (188)                                | 3   | 2.9  | 105              | 22—307               | —     | 0.4  | ..               | ..                   |
| Lymphoma (200—202)                           | 4   | 2.0  | 203              | 55—520               | —     | 0.9  | ..               | ..                   |
| Hodgkin's disease (201)                      | 2   | 0.8  | ..               | ..                   | —     | 0.2  | ..               | ..                   |
| Leukemia (204—207)                           | 4   | 1.9  | 215              | 59—551               | 3     | 1.1  | 273              | 56—797               |

<sup>a</sup> Code of the International Classification of Diseases, eighth revision, in parentheses.

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

<sup>c</sup> Including nasal cavity, auditory tube, middle ear, and paranasal sinuses.

<sup>d</sup> Excluding melanomas and basal cell carcinomas.

There were no cases of nasal cancer among either the men (0.2 expected) or the women (0.1 expected). There were no soft-tissue sarcomas among the men (0.4 expected), but there was one among the women (0.2 expected).

The findings for the workers employed for the first time after 1 January 1945 were similar to those for the whole cohort. The risk of primary cancer was increased both among the men (36 observed, 28.1 expected, SIR 128, 95 % CI 90—177) and the women (27 observed, 21.9 expected, SIR 123, 95 % CI 81—179). Among the men of this group, there was a distinct excess of skin cancer (4 observed, 0.7 expected, SIR 615, 95 % CI 168—1576). Three of these cases occurred after 15 years or more since first employment, versus 0.4 expected. There were also excesses of colon cancer (3 observed, 1.0 expected, SIR 294, 95 % CI 61—860) and lung cancer (12 observed, 8.2 expected, SIR 146, 95 % CI 75—255) among the men of this group.

The prevalence of smoking among male sawmill workers aged 15 to 69 years had not changed from 1956 to 1981. In 1956 the prevalence was 51.3 %, the standard error (SE) of the proportion being 5.6, and in 1981 the prevalence was 51.4 (SE 8.7) %. The prevalence among the male sawmill workers in 1981 was higher than among Finnish pulp and paper workers, 37.3 % in 1981 (17), and also higher than among the general Finnish male population, 44 % in 1976 (18). Among the female sawmill workers, the prevalence of smoking was 9.1 (SE 3.9) % for 1956 and 8.3 (SE 6.0) % for 1981.

## Discussion

This study showed a slight excess of primary cancers among both male and female sawmill workers, especially among those employed for the first time after 1 January 1945. Because of the results of previous studies, we were especially interested in certain types of cancer, particularly in nasal cancer, other types of respiratory cancer, soft-tissue sarcoma, leukemia, and lymphoma.

The most interesting finding proved to be the increased risk of skin cancer among the male sawmill workers. It had not been reported earlier. Four of the six cases of skin cancer among the men occurred among workers employed for the first time after 1 January 1945 (versus 0.7 expected). It is possible that the excess risk of skin cancer is associated with workplace chemical exposure, and especially the role of chlorophenols should be carefully evaluated. However, two of the eight subjects with skin cancer had not been exposed to chlorophenols.

Kauppinen & Lindroos (19) have measured personnel exposure to chlorophenols in ten Finnish sawmills. The concentrations of chlorophenols in the air were usually below the maximal allowable concentration of 0.5 mg/m<sup>3</sup>. However, rather high (up to 210.9 µmol/l) concentrations were detected in the urine of loaders when the through-dipping method was used, as well as in the urine of workers in the trimming-grading department (up to 85.0 µmol/l) (20). These workers had skin contact with chlorophenols, and skin absorp-

**Table 3.** Job titles and occupational exposures of sawmill workers with skin cancer, lymphoma, or leukemia, with calendar-years of employment and year of cancer diagnosis.

| Sex of worker                                      | Job held in sawmill | Workplace exposure <sup>a</sup>      | Calendar-years of employment | Year of cancer diagnosis |
|----------------------------------------------------|---------------------|--------------------------------------|------------------------------|--------------------------|
| <i>Skin cancer (173)<sup>b, c</sup></i>            |                     |                                      |                              |                          |
| Female                                             | { Loader            | Wood dust, chlorophenols             | 1945—1946 & 1951—1966        | 1973                     |
|                                                    | { Cleaner           | Wood dust, chlorophenols             | 1946—1948                    |                          |
| Male                                               | Loader              | Wood dust, chlorophenols             | 1947—1976                    | 1980                     |
| Male                                               | Loader              | Wood dust, chlorophenols             | 1945—1967                    | 1975                     |
| Female                                             | Registrar           | Wood dust, slightly to chlorophenols | 1946—1961                    | 1979                     |
| Male                                               | Log yard worker     | —                                    | 1945—1964                    | 1965                     |
| Male                                               | { Guard             | —                                    | 1945—1960                    | 1963                     |
|                                                    | { Helper            | Wood dust, chlorophenols             | 1961—1964                    |                          |
| Male                                               | { Guard             | —                                    | 1947                         | 1958                     |
|                                                    | { Fireman           | —                                    | 1947—1951                    |                          |
| Male                                               | Helper              | Wood dust, chlorophenols             | 1946—1948                    | 1962                     |
| <i>Non-Hodgkin lymphoma (200, 202)<sup>b</sup></i> |                     |                                      |                              |                          |
| Male                                               | Log yard worker     | —                                    | 1945—1954                    | 1966                     |
| Male                                               | Pumper              | —                                    | 1951—1963                    | 1964                     |
| <i>Hodgkin's disease (201)<sup>b</sup></i>         |                     |                                      |                              |                          |
| Male                                               | { Helper            | Wood dust                            | 1945—1959                    | 1973                     |
|                                                    | { Grinder           | —                                    | 1960—1973                    |                          |
| Male                                               | Supervisor          | Wood dust                            | 1945—1961                    | 1954                     |
| <i>Leukemia (204—207)<sup>b</sup></i>              |                     |                                      |                              |                          |
| Female                                             | Helper              | Wood dust, chlorophenols             | 1945—1950                    | 1974                     |
| Male                                               | Guard               | —                                    | 1945—1958                    | 1959                     |
| Male                                               | Chief engineer      | —                                    | 1945—1955                    | 1976                     |
| Female                                             | Cleaner             | Wood dust, chlorophenols             | 1945—1960                    | 1977                     |
| Female                                             | Helper              | Wood dust, chlorophenols             | 1952—1972                    | 1976                     |
| Male                                               | { Carpenter         | Wood dust                            | 1945—1959                    | 1960                     |
|                                                    | { Fire guard        | —                                    | 1960—1961                    |                          |
| Male                                               | Helper              | Wood dust, chlorophenols             | 1946—1948                    | 1962                     |

<sup>a</sup> Only major exposures mentioned.

<sup>b</sup> Code of the International Classification of Diseases, eighth revision, in parentheses.

<sup>c</sup> Excluding melanomas and basal cell carcinomas.

tion appeared to be the main route of exposure in the sawmills.

Commercial chlorophenol products have been found to contain impurities such as chlorinated phenoxyphenols, chlorinated diphenyl ethers, chlorinated dibenzofurans, and chlorinated dibenzodioxins (21). Some of these compounds are highly toxic and carcinogenic even in low concentrations. It should be noted that not all sawmill workers have been exposed to chlorophenols, and it is therefore difficult to assess the possible carcinogenic risk of these compounds in general sawmill worker cohorts without careful job-based analyses. The chlorophenol exposure has been the highest among those working in the timber dipping area or handling timber still wet after chlorophenol treatment, but workers in the trimming-grading plant of the sawmill have also been exposed to wood dust containing chlorophenols.

The slightly increased risk of lymphomas among the men was in accordance with the results of some earlier studies (9, 10). One paper has reported excess deaths

from leukemia among sawmill workers (9), but another (22) showed no increased risk of leukemia. In the present study, the risk of leukemia was slightly increased, among both the men and the women, but the lower 95 % confidence interval was below 100.

The risk of lung cancer was not increased among the men in the whole cohort, but was somewhat increased among those who had been employed for the first time after 1 January 1945. There was an increased risk of lung cancer both among the women in the total cohort and among those employed after 1 January 1945, but the numbers of the observed and expected cases were low.

The use of chlorophenols in the sawmill of this study began in 1945; otherwise workplace exposure has been the same for the whole cohort and for those employed for the first time after 1 January 1945. However, no clear association can be established between exposure to chlorophenols and lung cancer because different smoking habits between the sawmill workers and the general population may partly explain the finding.

Wood dust is typical workplace exposure in sawmills, but in general the exposure levels have not been very high (23, 24). According to Kauppinen et al (23), the dust concentrations were generally below 1 mg/m<sup>3</sup>, but exceeded 3 mg/m<sup>3</sup> during cleaning operations, the control of chipmaking machinery, and the removal of moldings.

Hernberg et al (6) recently found an association between nasal cancer and exposure to softwoods. The findings of our present study were not consistent with theirs, as no nasal cancer cases were found, but it should be noted that the expected numbers of nasal cancer were very low.

There have been no earlier reports of an increased risk of colon cancer or rectal cancer among sawmill workers. The numbers of the observed and expected cases of these cancer types in the present study were so low that no conclusions can be drawn from the observed statistically nonsignificant excesses. Contrary to the results of an earlier report (25), there were no excesses of laryngeal cancer in this study.

Not much can be said about the possible "healthy worker effect" among sawmill workers, but it certainly exists also in this industry. It would be interesting to study a cohort of sawmill workers without any chlorophenol exposure, but the number of those workers, at least in the sawmill of the present study, would be rather low for a proper cohort.

In conclusion, although only a slight excess of primary cancers was observed among the sawmill workers studied, there was an excess of skin cancer, especially among the men. This excess may be associated with workplace exposure, but the possible association needs to be further evaluated with special emphasis on specific jobs with well-defined exposure data.

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