International Journal of Occupational Medicine and Environmental Health, Vol. 11, No 3, 217–225, 1998

ORIGINAL PAPERS

CANCER RISK IN WORKERS OF THE PULP AND PAPER INDUSTRY IN POLAND. A CONTINUED FOLLOW-UP

IRENA SZADKOWSKA-STAŃCZYK, WIESŁAW SZYMCZAK, NEONILA SZESZENIA-DĄBROWSKA and URSZULA WILCZYŃSKA*

Department of Epidemiology
The Nofer Institute of Occupational Medicine
Łódź, Poland

Key words: Cancer mortality, Pulp and paper industry, Cohort study

Abstract. A mortality cohort study was undertaken among Polish pulp and paper workers. This paper concentrates on neoplasms mortality among men and women employed continuously for at least one year in the factory producing sulphate pulp, paper board and paper products. A retrospective observation carried out till 31 December 1995 covered 10.460 workers employed during the years 1968–1990. The cohort accessibility was 99%. Cancer risk was evaluated on the basis of standardized mortality ratio (SMR) calculated according to the person-years method. The general population of Poland was the reference population. The results of a 23-year cohort observation, published earlier, showed a lowered overall mortality from all causes and from all malignant neoplasms, and a significant excess of death from peritoneum and prostate cancer among pulp mill male subcohort. The conclusion was drawn that a 'young' cohort and relatively short follow-up period might have affected the results. The results presented in this paper, obtained after further five years of observation showed in the male cohort an excess of deaths from cancer of respiratory tract and peritoneum (lung SMR = 122, nasal cavities SMR = 587, peritoneum SMR = 562). An approximate correction for smoking habits resulted in only 4 decreased risk estimates for lung cancer, indicating a small positive confounding effect of smoking in this material. In female cohort an excess of brain cancer was found (SMR = 355). Only the excess mortality from cancers of nose, lung and peritoneum was coherent with the exposure to higher concentrations of wood dust, pulp, paper and board dust. It may support a hypothesis that these factors as well as dust pollutants, not yet identified in this study, may be considered as one of the risk factors contributing to the incidence of neoplasms of these sites.

* The article is based on a paper presented at the 12th International Symposium on Epidemiology in Occupational Health, Harrare, Zimbabwe, September 16–19, 1997.

Address reprint requests to I. Szadkowska-Stańczyk M.D., Department of Environmental Epidemiology, The Nofer Institute of Occupational Medicine, P.O. Box 199, 90-950 Łódź, Poland.

INTRODUCTION

Numerous studies carried out in groups of workers employed in the pulp and paper industry have highlighted an elevated mortality from cancers of specified sites. Excess mortality from cancer of lung (2,4,15,16,17), stomach and intestines (2,4,6,8,9,18), lymphatic (5,6,8,10) and haematopoietic tissue (5,16), nasal, sinonasal (3,7,8,9) and laryngeal cancers (9), is reported most frequently.

The objective of our study was to assess the risk of malignant neoplasms among workers engaged in the pulp and paper production.

MATERIALS AND METHODS

The study covered workers of one of the biggest pulp and paper mills with about 4,000 employees, set up in 1967. The mill is located in the town inhabited by 35 thousand people. Most of them find their jobs in the mill. The production embraces mainly: softwood kraft pulp from pine, dissolving pulp from beech and birch, pulping of recycled paper, paper bleached and unbleached, sack paper, wrapping paper, paper and board container and corrugated board.

In this investigation a historical cohort study design was utilized. The cohort consisted of workers employed in the mill for at least one year between 1968 – 1990. The cohort had been observed over a period of 27 years until 31 December 1995. For each person deceased in that period, the cause of death was identified. Causes of death taken from death certificates were coded by a physician according to the International Classification of Diseases (ICD, 9th Revision). In cases of death from selected cancers, an attempt was made to verify them histopathologically against the files of the National Oncological Centre, but these data, available only for cases of deaths observed in the cohort, were not used in the analysis presented in this paper.

Workers under observation were assigned to three subcohorts, formed according to work areas:

1. Workers involved in the pulp production;
2. Workers involved in the paper production;
3. Workers employed in non production departments.

Statistical analysis was based on standardized mortality ratio (SMR). Mortality rates for the general population of Poland were used to calculate expected deaths.

The age, sex and calendar period specific numbers of person-years at risk in the cohort were multiplied by the corresponding death rates. Standardized mortality ratios were obtained as the ratios of the observed to the expected numbers of cases. The Poisson distribution was used when testing for the statistical significance of the differences between the observed and expected numbers of death and when calculating the 95% confidence intervals for SMRs. Due to the small number of deaths recorded, analyses by the exposure duration and latency period were performed for the selected neoplasm sites only.

In this study the prevalence of smoking was also assessed, based on the survey data collected in a random sample of workers enrolled in the cohort. Interviewers provided information on smoking among current and former workers; in the case of deceased, relevant data was obtained by interviewing their next of kin or, exceptionally, from the medical files. These data were available for 219 (98,6%) of 222 men. The information from this random sample were used to evaluate

approximately a possible confounding effect of smoking with regard to lung cancer. Reference data regarding smoking habits in Polish male population, at the appropriate time period, were taken from several, comparable published investigations (20). In an alternative analysis resulting in the Appendix, statistical adjustment of SMR for the effect of smoking was done by the method suggested by Axelson (1).

RESULTS

A total of 10,575 employees (7,084 males and 3,491 females) had been observed until 31 December 1995. The cohort verification rates were 99%; 654 male and 113 female deaths were identified. The underlying cause of death was determined for 99% of deaths (Table 1).

Table 1. Follow-up and vital status of the cohort (1968-1990) traced until 31 December 1995

	Males	Females
Total in study	7084	3491
Traced	6993 (98.7%)	3460 (99.1%)
Deceased	654	113
of which: those with known cause of death	646 (98.8%)	112 (99.1%)

As shown in Table 2, over a period of 28 years (1967 – 1995) study subjects in the cohort contributed roughly 210,000 person-years of observation (about 140,000 from males and over 70,000 from females). The length of employment at the pulp and paper mill accounted for 10 years on average, and the mean length of observation was 20 years. The exposure assessment revealed that workers had been exposed mainly to wood dust, terpenes, hydrogen sulfide, mercaptans, chlor, chlorine dioxide, pulp and paper dust. The threshold limit values of these factors were periodically exceeded.

Table 2. Number of workers and person-years of observation in the entire cohort and subcohorts by sex

Subcohorts	Males		Females	
	No. of workers	Person-years	No. of workers	Person-years
Pulp mill	1469	27842.1	548	11422.7
Paper and board mill	1362	24647.0	1921	36601.5
Non production depts	5175	100022.4	1722	36330.0
Total	7052	137253.4	3465	71451.4

Table 3 shows that in the male cohort mortality from all causes was positively lower than expected, whereas mortality from malignant neoplasms was similar to that in the referent population. The table presents only neoplasm sites with higher number of the observed than expected deaths. An increased risk of death from cancer of peritoneum deserves special attention. SMR = 562 indicates the risk elevated by five times in comparison with the general population. Risk of mortality from neoplasms

Table 3. Cancer mortality by selected sites in males. Total cohort

Cause of death [a] (9th ICD)	OBS [b]	EXP [c]	SMR [d]	95% CI [e]
All causes (000–999)	654	851.9	77	71–83
All malignant neoplasms (140–208)	172	176.0	98	84–114
Tongue (141)	2	1.3	155	19–560
Pharynx (146–148)	3	2.4	127	26–371
Peritoneum (158)	3	0.5	562*	116–1642
Respiratory system (160–165)	81	69.1	117	93–145
Nasal cavities and sinuses (160)	2	0.3	587	71–2120
Lung (162)	73	59.6	122	96–153
Pleura (163)	1	0.3	288	
Soft tissue sarcoma (171)	1	0.6	174	
Malignant melanoma (172)	4	1.8	217	59–556
Other malignant n. of skin (173)	3	0.7	430	89–1257
Prostate (185)	5	4.1	121	39–282
Testis (186)	2	1.6	126	15–455
Bladder (188)	6	4.7	128	47–279
Brain (191)	8	6.7	119	51–234

* significant at 5% level.

a) Code of the International Classification of Diseases, ninth revision, in parentheses

b) OBS – observed deaths

c) EXP – expected deaths

d) SMR – standardized mortality ratio

e) Confidence interval (CI) was not calculated when OBS $\leqslant$ 2

of the respiratory system was slightly increased (SMR = 117). In this group of pathologies there were noted two cases of nasal and sinonasal cancer (SMR = 587) at a very low value of the expected deaths (0.3), and 73 cases of lung cancer with SMR = 122. One case of mesothelioma pleurae was also detected (expected deaths = 0.35 produced SMR = 288). It seems advisable to mention as well an elevated risk of rather rare cancer of tongue and pharynx. In addition, excess mortality from cancer of other sites (like skin, prostate, testis, bladder and brain), was reported, however, the SMR values were statistically insignificant. It should be stressed that in the male cohort, mortality from cancer of stomach and intestines as well as from cancer of lymphatic and haematopoietic tissue, found by other authors, was much lower than expected.

The analysis of mortality from neoplasm of peritoneum and neoplasm of respiratory organs in individual cohorts indicated a significantly elevated risk of mortality from neoplasm of peritoneum in workers employed in the pulp production (Table 4). Two cases of neoplasm of this site were recorded in this subcohort: a cook and a chlorine dioxide operator, both exposed to such irritating factors as: chlorine, chlorine dioxide, sulfur dioxide, mercaptans and hard wood and pulp dusts. A railway transport worker proved to be another case. The risk from neoplasm of respiratory organs was increased mainly in workers at the paper production where exposure to paper dust predominated. However, nasal cancer occurred in workers of non-production departments. Two cases were recorded in transport workers (loader

Table 4. SMR values by selected sites of neoplasms and male subcohorts

	Pulp	Paper	Non production	Total
Peritoneum	1716**	–	250	562*
Respiratory system	124	152	116	117
Nasal, sinonasal	–	–	772	587
Lung	130	166	121	122
Pleura	–	171	–	288

*significant at 5% level
**significant at 1% level

Table 5. Lung cancer SMRs in the male cohort, by latency and exposure period

	Latency (years)		
	< 10	10–19	20 <
SMR	105	120	132
	Exposure (years)		
	< 10	10–19	20 <
SMR	139*	95	120

*significant at 5% level

Table 6. Cancer mortality by selected sites in females. Total cohort

Cause of death [a] (9th ICD)	OBS [b]	EXP [c]	SMR [d]	95% CI [e]
All causes (000–999)	113	133.7	84	69–101
All malignant neoplasms (140–208)	43	43.2	99	72–133
Liver and gallbladder (155–156)	3	2.7	111	23–324
Pancreas (157)	2	1.3	148	18–535
Respiratory system (160–165)	6	3.6	164	60–357
Larynx (161)	1	0.2	546	
Lung (162)	5	3.1	162	53–378
Malignant melanoma (172)	1	0.7	133	
Female genital organs (179–184)	13	10.9	120	64–205
Brain (191)	7	2.0	355*	143–731

*significant at 5% level

a) Code of the International Classification of Diseases, ninth revision, in parentheses
b) OBS – observed deaths
c) EXP – expected deaths
d) SMR – standardized mortality ratio
e) Confidence interval (CI) was not calculated when OBS ⩽ 2

and driver) exposed to wood dust and exhaust gas. Due to relatively large number of persons with lung cancer it was feasible to assess risk by duration of exposure and latency. Length of employment was used as a surrogate exposure index. As shown in Table 5, the highest SMRs were related to latency above 20 years, but such relationship was not revealed in regard to length of employment in the mill. The highest risk was found in persons with employment less than 10 years.

In the female cohort, 113 deaths were recorded (Table 6) Like in the male cohort, mortality from all causes was lower than that in the general population of Poland. Mortality from all malignant neoplasms corresponded with mortality risk in the referent population (SMR = 99). The table presents only sites of neoplasms with higher number of the observed than expected deaths. Based on seven deaths observed and two deaths expected, a three-fold increase in the risk of mortality from brain cancer was noted. We managed to verify those neoplasms histopathologically in 70% of cases only. The analysis of SMRs by subcohorts (Table 7) indicated the highest risk of mortality from brain cancer in females employed in the paper production. The analysis of SMRs by the length of employment (Table 8) showed a higher risk in females employed for a period longer than 10 years while the analysis by latency revealed the highest SMRs for the period of 10–19 years. Of seven cases of brain cancer, six were found in women working in production departments; five of them were involved in the paper production and one in pulp recycling. As appears from the information available at the mill, all the women were primarily exposed to paper and board dust.

Table 7. Brain cancer SMRs in female subcohorts

	Pulp	Paper	Non-Prod	Total
SMR	280	553*	176	355*

*significant at 5% level

Table 8. Brain cancer SMRs in female cohort by latency and exposure period

	Latency (years)		
	< 10	10–19	20 <
SMR	194	567*	175
	Exposure (years)		
	< 10	10–19	20 <
SMR	321	543*	–

*significant at 5% level

DISCUSSION

The results of a 23-year cohort observation, that have been published earlier (11–14), showed the lowered overall mortality (which was explained by a 'healthy worker effect') and the excess of deaths from malignant neoplasms for some sites (peritoneum, prostate, brain). Due to the small number of deaths recorded, exposure duration and its kind were left out of the analysis.

To sum up the results presented in this paper, it should be stressed that mortality from all causes was still lower than that in the referent population. A statistically significant overall mortality deficit of approximately 20% was reported. This observation usually results from a combination of several factors associated with employment: selection for health at hire, medical care and a lifestyle

afforded by stable employment (19). The risk of mortality from all malignant neoplasms, determined in our study, both in the male and female cohorts, was not higher than that in the general population. However, excess male cancer of peritoneum, upper and lower respiratory tract, tongue and pharynx, represents the sites where exposure to hard wood, paper and pulp dust may be considered as a risk factor. Although, the analysis of the production technology, utilized in the mill, did not reveal that asbestos fibres had contributed to the environment pollution, such a possibility cannot be excluded, particularly in maintenance departments.

The interpretation of the association between exposure at work and lung cancer is difficult because of tobacco smoking confounder. During the period of cohort observation, the proportion of smokers and ex-smokers in the general population of Poland was 75% to 25%, respectively (20). In the cohort it was 78% to 22%. Assuming that there is a 20-fold increase in lung cancer risk for smokers and ex-smokers as compared to nonsmokers, the relative risk of death from lung cancer, calculated according to Axelson (1), was slightly higher – 1.04 (Appendix) in the group where smoking was more prevalent than in the general population. After correcting the SMR value, the risk of death from lung cancer in the cohort was still elevated (SMR = 118), which indicates that there might be an association between lung cancer and occupational exposure. Excess mortality from skin cancer in non production workers was most likely related to factors not specific for the pulp and paper production. An elevated risk of cancer of prostate, testis and bladder cannot be elucidated without in-depth identification of exposure to harmful factors. A significant excess of brain cancers in the female cohort is another problem that requires further investigations. The assessment made in this study (primarily exposure to paper dust) does not allow any causal conclusions to be drawn, regarding specific hazardous exposures in this work environment. The issue of female brain cancer in this branch of industry needs to be further elucidated. This analysis, similar to previous results, did not confirm excess mortality from stomach, lymphatic and hematopoietic tissue neoplasms found in other pulp and paper plants.

In conclusion, an elevated risk of mortality from malignant neoplasms of the lower and upper respiratory tract and peritoneum, reported in the male cohort, may support a hypothesis that wood, pulp and paper dust as well as dust pollutants not yet identified in this study may be considered as one of risk factors contributing to the incidence of neoplasms of these sites.

ACKNOWLEDGEMENTS

This study was supported by the Nofer Institute of Occupational Medicine grant No 10.3/97.

REFERENCES

1. Axelson O. Aspects on confounding in occupational health epidemiology. Scand J Work Environ Health 4: 98–102, 1978.
2. Henneberger PK, Ferris BJr, Monson RR. Mortality among pulp and paper workers in Berlin, New Hampshire. Br J Ind Med 46: 658–664, 1989.
3. Hernberg S, Westerholm P, Schultz-Larsen K et al. Nasal and sinonasal cancer: connection with occupation and exposure in Denmark, Finland and Sweden. J Work Environ Health 9: 315–326, 1983.
4. Jappinen P, Hakulinen T, Pukkala E, Tola A, Kurppa K. Cancer incidence of workers in the Finnish pulp and paper industry. Scand J Work Environ Health 13: 3, 197–202, 1987.

5. Milham S. Occupational mortality in Washington State, 1950–79. NIOSH No 83–116, US Department of Health Services, Cincinnati 1983.
6. Milham S, Demers R. Mortality among pulp and paper workers. J Occup Med 26: 844–846, 1984.
7. Nylander LA, Dement JM. Carcinogenic effect of wood dust: review and discussion. Am J Ind Med 24: 619–647, 1993.
8. Robinson CF, Waxweiler RJ, Fowler DP. Mortality among production workers in pulp and paper mills. Scand J Work Environ Health 12: 552–560, 1986.
9. Schwartz E. A proportionate mortality ratio analysis of pulp and paper workers in New Hampshire. Br J Ind Med 45: 234–238, 1988.
10. Svirchev LM, Gallagher RP, Band PR, Threlfall WJ, Spinelli JJ. Gastric cancer and lymphosarcoma among wood and pulp workers. J Occup Med 28: 4, 264–265, 1986.
11. Szadkowska-Stańczyk I, Wilczyńska U, Szymczak W. Mortality in a cohort of pulp and paper workers. Med Pr 2: 111–120, 1995 (in Polish).
12. Szadkowska-Stańczyk I, Wilczyńska U, Szymczak W. Risk of death from malignant neoplasms among the pulp mill workers. Med Pr 6: 575–581, 1995 (in Polish).
13. Szadkowska-Stańczyk I., Wilczyńska U, Szymczak W. Risk of death from malignant neoplasms among paper mill workers. Med Pr 6: 542–546, 1996 (in Polish).
14. Szadkowska-Stańczyk I, Boffetta P, Wilczyńska U, Szeszenia-Dąbrowska N, Szymczak W. Cancer mortality among pulp and paper workers in Poland. A cohort study. Int J Occup Med Environ Health 1: 19–29, 1997.
15. Thoren K, Jarvholm B, Morgan U. Mortality from asthma and chronic obstructive pulmonary disease among workers in a soft paper mill: a case-referent study. Br J Ind Med 46: 192–195, 1989.
16. Thoren K, Sallsten G, Jarvholm B. Mortality from asthma, chronic obstructive pulmonary disease, respiratory system cancer and stomach cancer among paper mill workers: A case-referent study. Am J Ind Med 19: 729–737, 1991.
17. Thoren K, Persson B, Wingren G. Health effects of working in pulp and paper mills: Malignant diseases. Am J Ind Med 29: 123–130, 1996.
18. Wingren G, Kling H, Axelson O. Gastric cancer among paper mill workers. J Occup Med 27: 715, 1985.
19. Wong O, Ragland D, Marcero D. An epidemiologic study of employees at seven pulp and paper mills. Int Arch Occup Environ Health 68: 498–507, 1996.
20. Zatoński W, Przewoźniak K. Health effects of smoking in Poland. Ariel, Warszawa 1992 (in Polish).

APPENDIX

ADJUSTMENT OF EXPECTED LUNG CANCER FOR DIFFERENCES IN SMOKING HABIT

The population of pulp and paper workers consisted of never smokers plus a mixture of current and former smokers. Assuming that the lung cancer risk factor for ever smokers compared with never smokers is 20, one may then compare the risk between populations containing 22% (this cohort) and 25% (general population) of never smokers respectively, using the method of Axelson (1).

$$I = I_{CF} \cdot P_{CF} + I_0(1 - P_{CF})$$

where:

I = overall incidence (deaths) of lung cancer,
I_{CF} = incidence as caused by the confounding factor (smoking),
P_{CF} = proportion of population with the factor in question (smokers),
I_0 = incidence among those without the risk factors (never smokers).

If the effect of the confounding factor is known (here R = 20 is chosen) the formula mav be rewritten as:

$$I = RI_0 \cdot P_{CF} + I_0(1 - P_{CF}).$$

Therefore in the general population

$I_G = (20)(I_0)(0.75) + I_0(0.25),$

$= 15.25\ I_0.$

In the study population

$I_S = (20)(I_0)(0.78) + I_0(0.22),$

$= 15.82\ I_0.$

Therefore, the relative risk in the study population due to a greater prevalence of smokers is

$$\frac{I_S}{I_G} = \frac{15.82}{15.25} = 1.04$$

Received for publication: October 15, 1997
Approved for publication: August 3, 1998