Update on the cohort study of pulp and paper workers in British Columbia

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In July 1997, the BC Cancer Agency published in the *American Journal of Epidemiology* (Am J Epidemiol 1997; 146:186-94) the cancer mortality results from an ongoing epidemiologic study of pulp and paper workers in British Columbia. A video and a list of questions and answers were distributed together with the peer-reviewed publication, summarizing the findings and providing interpretation. This document provides updates of the study on the cancer incidence results through a list of questions and answers. The results appear in the current issue of the Scandinavian Journal of Work, Environment and Health (Scand J Work Environ Health 2001: 27(2): 113-119). A copy of the paper can be obtained at http://bccancer.bc.ca/research/ccr/people/nle/pp_finalinc.pdf. For more information about the study, contact Dr. Band at pband@hc-sc.gc.ca or Dr. Le at nle@bccancer.bc.ca.

Background: The total cohort consisted of 30,157 male pulp and paper workers with at least one year of employment between 1950 to 1992. Of these, 20,373 (68%) worked in the kraft process, 5,249 (17%) in the sulfite process and 4,535 (15%) in both processes. The cancer experience of this cohort of workers was compared with that of the Canadian male population. The standardized incidence ratio (SIR) was used for comparisons with population cancer incidence data available since 1969. An SIR of 1 means that the cancer incidence rate in the cohort and in the general population are the same. An elevated SIR, as reflected by an SIR greater than 1, means that the cancer rate of the cohort is greater than that of the general population. An SIR greater than one may or may not be statistically significant.

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Questions and Answers:

Q: What are the main findings of the cancer incidence study?

The results indicate statistically significant excess risks for work duration of 15 or more years, for the following cancer sites:

a) All workers: Skin melanoma (26 cases, SIR=1.78), cancer of the pleura (6 cases, SIR=2.8), and of the prostate (175 cases, SIR=1.24).
b) Workers in the kraft process: Skin melanoma (15 cases, SIR=1.73).
c) Workers in the sulfite process: Skin melanoma (3 cases, SIR=2.65), cancer of the rectum (11 cases, SIR=1.90), and of the pleura (3 cases, SIR=16.84).
d) Workers employed in both the kraft and sulfite processes: cancer of the stomach (21 cases, SIR=1.55) and of the prostate (82 cases, SIR=1.44), leukemias (14 cases, SIR=1.66).

Q: What are the causes for differences in cancer rates?

There are several potential causes leading to the differences in cancer rates, including occupational exposure, genetic predisposition, lifestyle and other risk factors. Information on lifestyle, genetic predisposition and other risk factors is not available in this retrospective study dating back to 1950.

Q: What do these findings mean?

These findings suggest that long term work in the industry is associated with an excess risk of skin melanoma, prostate and pleural cancers. It should be noted that British Columbia has significantly higher skin melanoma incidence rates than the Canadian population. Since 94% of the pulp and paper cohort has been traced in British Columbia, we have re-analyzed the data using British Columbia rates. The excess risk for skin melanoma became non-significant statistically. The excess risk of pleural cancer likely reflects past asbestos exposure since 90% of these cases were malignant mesotheliomas. We are currently investigating the potential exposures that might be associated with the increased prostate cancer risk.

Additionally a significant excess risk for stomach cancer and leukemias is observed among long term workers employed in both processes, as well as for cancer of the rectum among long term workers employed in the sulfite process only. Potential chemical exposures associated with the increased risk will be further examined.

Q: What are the different findings between this study and the mortality one?

The significantly increased mortality cancer risks suggested in the mortality were not confirmed in this cancer incidence study, including

a) All workers: brain, and kidney cancer
b) Workers in kraft process: kidney cancer
c) Workers in sulfite process: Hodgkin's disease
d) Workers in both processes: Esophageal cancer.

Q: Why are these differences?

Discrepancies between cancer diagnosis listed on pathology reports and cause of death listed on death certificates caused the differences for kidney, brain and esophageal cancer. It should be emphasized that the cancer diagnosis based on pathologic diagnosis, is generally more accurate.

For Hodgkin's disease, a sub-analysis of the mortality showed that the increased risk was confined to the period 1950-1968. For the period 1969-1992, the cancer incidence and mortality risks are similar, showing no excess.

Q: What is the current plan for further study?

The second phase of the cohort study, the case control component, is being carried out. Mill specific job-exposure matrices are completed for detailed chemical exposure assessments. This case-control component will identify chemicals or groups of chemicals as potential risk factors for cancers.

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COHORT CANCER INCIDENCE STUDY OF PULP AND PAPER MILL WORKERS IN BRITISH COLUMBIA, CANADA.

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Abbreviations: NHL, non-Hodgkin's lymphoma; CI, confidence interval; SIR, standardized incidence ratio.

ABSTRACT

Objectives: A study was conducted to investigate cancer risks in a cohort of pulp and paper workers.

Subjects and methods: All male workers with at least 1 year of employment in 14 pulp and paper mills on January 1, 1950 or thereafter until December 31, 1992 were studied. The main industrial process of these 14 mills was pulping, whereas seven also included paper-making. Standardized incidence rations (SIRs) were used to compare the cancer incidence of the cohort with that of the Canadian male population. Record linkage with the National Cancer Registry, which dates back since 1969, was performed at Statistics Canada using the generalized iterative record linkage method.

Results: A total of 1756 cancer cases was observed in the entire cohort: 850 among 20041 workers employed in the Kraft process only, 464 among 3756 workers employed in the sulfite process only, and 442 among 4481 subjects who worked in both processes. Significantly increased SIRs related to work duration of 15 years or longer were noted for pleural and prostate cancer and for skin melanoma in the entire cohort, and for the following cancer sites in the three subcohorts: 1) workers employed in the Kraft process only: skin melanoma; 2) workers employed in the sulfit process only: cancer of the rectum; 3) workers employed in both Kraft and sulfite processes: cancer of the stomach and of the prostate, and all leukemias combined. A separate analysis comparing workers exposed to pulp and paper-making to those exposed only to the pulping process did not reveal differences in cancer risks and hence did not modify these results. SIRs for skin melanoma were not significantly increased when the British Columbia male population

incidence rates were used. Nine of the 10 pleural cancers were mesotheliomas and likely reflect past asbestos exposure.

Conclusions These findings suggest that long term work in the pulp and paper industry is associated with an excess risks of prostate and stomach cancers and all leukemias for workers employed in both Kraft and sulfite processes, and of rectal cancer for those employed in the sulfite process only.

Key terms sulfite, kraft; stomach cancer, rectal cancer, prostate cancer, leukemias.

INTRODUCTION

Pulp and paper is a major industry in Canada and a primary one in British Columbia, the most westerly Canadian province. Wood may be converted to pulp by a number of processes, the most prevalent in Canada being chemical. In chemical pulping, lignin is solubilized under two conditions: alkaline, also called kraft or sulfate process, and acidic or sulfite process, the former being the most common. During chemical pulping, exposures to known or suspected carcinogens may occur including exposure to organic chlorinated compounds, sulfuric acid mist and formaldehyde, and to arsenic and chloroform previously used as antisap stain although exposure to the latter two compounds are usually small. In a previous publication, we reported the cancer mortality experience, by type of chemical pulping process, of a cohort of 30157 pulp and paper workers in British Columbia (1). Cancer risks significantly associated with work duration and time from first employment of 15 years or more were observed in the total cohort for cancer of the pleura, kidney and brain; in kraft mill workers only, for kidney cancer; in sulfite mill workers only, for Hodgkin's disease; in workers ever employed in both kraft and sulfite mills, for esophageal cancer. Epidemiologic studies specifically designed to investigate pulp and paper workers have mainly been mortality studies (2-14), with only 3 reporting cancer incidence results (15-17). This report presents the cancer incidence outcomes of 28278 members of the British Columbia pulp and paper cohort.

SUBJECTS AND METHODS

Details of the methods were previously described (1). Before initiating the study, a feasibility study was conducted with the following eligibility criteria for pulp and paper

mill inclusion: 1) start of production in 1970 or earlier; 2) minimum of 1,000 workers ever employed by the mill; 3) availability of records for all employees. Of the 21 mills in British Columbia, 14 met these criteria and were included in the study. The main industrial process of these 14 mills was pulping, whereas seven also included paper-making. All male workers with at least 1 year of employment in these 14 mills as of or since January 1, 1950 until December 31, 1992, the cutoff date for follow-up were enrolled in the cohort. Data collection included full name and dates of birth, hire, and termination of employment. Information on tobacco smoking and other cancer risk factors related to lifestyle was not available.

The mortality cohort consisted of a total of 30157 workers (1). Of these, 1889 (6.3%) were excluded from the cancer incidence cohort due to the following events which occurred prior to 1969: 1134 were lost to follow-up, 552 died from non cancer causes, 175 had been diagnosed with cancer. Previously missing birth date information from the mortality cohort was found for 10 workers who were added to the incidence cohort. Thus, a total of 28278 workers were included in the analysis. The characteristics of the cohort are shown in table 1. Of the 28278 workers, 20,041 (70.9%) worked in the kraft process only, 3,756 (13.3%) in the sulfite process only, and 4,481 (15.8%) in both processes. All 28278 workers were exposed to the pulping process. The number of workers also exposed to the paper-making process in the total cohort and in the 3 subcohorts was: 1) all workers: 16080 (56.9%); 2) workers employed in the Kraft process only: 12647 (63.2%); workers employed in the sulfite process only: 942 (25.1%); workers employed in both Kraft and sulfite processes: 2491 (55.6%). Over 95 percent of the workers in all processes were successfully traced.

Statistical procedure

Standardized incidence ratios (SIRs) were used to compare the cancer incidence of the cohort with that of the Canadian male population. Canadian population incidence rates, obtained from the Laboratory Centre for Disease Control, Health Canada, were calculated by 5-year age groups and 5-year calendar periods dating back to January 1,1969. Person-years at risk were calculated from 1 year after the date of hire to December 31, 1992, or to the year of death or of cancer incidence whichever came first. For workers lost to follow-up, observations were censored at the date when last known to be alive. Latency effects were examined using work duration and time since first employment calculated from 1 year after the date of hire. Time since first employment was calculated to the last follow-up date. A 15 years latency cutoff was selected because the person-year distribution of all workers with time from first exposure of 15 years or over (210,546 person-years) was equally distributed between those with less than 15 years of employment (110,211 or 52%) and those with 15 or more years of employment (100,235 or 48%). Similarly, the total number of cancer cases in these two subgroups was almost equal (685 versus 724). Tests of significance and of the SIRs were calculated assuming that the observed number of events followed a Poisson distribution with the mean given by the expected number of events (18); 90 percent confidence intervals (CI) corresponding to a one-sided 5 percent significance test were used. Record linkage of the cohort with the National Cancer Registry was performed at Statistics Canada using the generalized iterative record linkage method (19, 20). In Canada, ascertainment of cancer incidence cases on a national basis dates back to 1969 (21); hence, the January 1st 1969

follow-up starting date of this study. Cancer diagnoses were coded according to the 9th revision of the International Classification of Diseases (22).

RESULTS

Incidence and latency analyses

Results of the cancer incidence analyses for the total cohort and by chemical processes are shown in table 2 for any cancer site with a minimum of four cases per site. Latency analyses are reported in tables 3-6 for work duration and time since first employment of < 15 years and ≥ 15 years; in these tables, data are shown for any cancer site with statistically significant increased or decreased SIRs or a non-significant excess risk of 50 percent or greater observed for work duration ≥ 15years.

Total cohort

A total of 1756 cancer cases was observed (table 1). SIRs for skin melanoma and for pleural, prostate, and eye cancer were elevated (table 2) and decreased for bladder cancer. SIRs for work duration greater than 15 years (table 3) were significantly increased for skin melanoma and for pleural and prostate cancer; relative risks were significantly decreased for all cancers and for the following cancer sites: tongue, mouth, pharynx, colon, lung and bladder.

Workers employed only in the kraft process

A total of 850 cancer cases was observed (table 1). SIRs for skin melanoma and for prostate, pleural and eye cancer were elevated (table 2); SIRs were decreased for all cancers and for cancer of the, pancreas, larynx, lung and bladder. For work duration greater than 15 years (table 4), relative risks were significantly increased for malignant

melanoma and significantly decreased for all cancers, and for the following cancer sites: tongue, mouth, pharynx, rectum, lung and bladder.

Workers employed only in the sulfite process

A total of 464 cancer cases was observed (table 1). SIRs for all cancers, cancer of the liver, pancreas, lung, connective tissue and brain were increased. For work duration greater than 15 years (table 5), SIRs were increased for cancer of the rectum and for skin melanoma.

Workers employed in both kraft and sulfite processes

A total of 442 cancer cases was observed (table 1). SIRs for cancer of the stomach, gallbladder and prostate and for skin melanoma were increased and decreased for bladder cancer. For work duration greater than 15 years (table 6), relative risks were increased for the following cancer sites: stomach, gallbladder, skin melanoma, prostate and for myeloid leukemias and all leukemias; relative risk was low for bladder cancer.

Comparison of workers exposed to the pulping and paper-making process with those exposed to the pulping process only

We analyzed the data comparing workers exposed only to the pulping process with those exposed to the pulping as well as the paper-making processes. These comparative analyses were carried out for all workers and for each of the three subcohorts. Results (data not shown) were similar to those described above considering pulping and paper making processes together, and did not reveal significant differences in cancer risks for workers exposed to the paper-making process in addition to the pulping process.

DISCUSSION

An increased incidence from several cancer sites was observed in the cohort of pulp and paper workers described in this study. Significantly elevated SIRs associated with work duration of 15 years or more, hereafter referred to as long term workers, were noted for cancers of the stomach, rectum, pleura and prostate, for skin melanoma and for all leukemias; numbers were too few to meaningfully assess, among long term workers, the elevated risk observed for eye cancer in the total cohort. Relative risk for stomach cancer was significantly increased among long-term workers exposed to both Kraft and sulfite processes. A risk of stomach cancer has been reported in mortality, case-control and incidence studies (2-4, 7, 8, 16) and associations between stomach cancer and chemicals to which workers in the pulp and paper industry are exposed to, particularly calcium oxide fumes, sulfur dioxide and sulfuric acid mists, have been described (24, 25). Dietary factors, particularly consumption of smoked, cured and salted food as well as cigarette smoking (26) which have been associated with an increased risk of stomach cancer cannot be excluded, since information on life-style factors was not available in our study. However, the fact that stomach cancer was observed among workers exposed to both Kraft and sulfite processes and not in those exposed only to the Kraft or to the sulfite process only suggests a role for combined occupational exposures. The association with rectal cancer among long-term workers in the sulfite process is difficult to interpret. Such a relationship has been reported in a mortality study (4), but in none of the incidence ones (15-17). The excess risk for pleural cancer likely represents past asbestos exposure (1, 23), since all except one of the 10 cases were mesotheliomas. The leukemia risk observed in our study, which has been previously reported in the pulp and paper industry (4-6, 16), was not related to any specific leukemia subtype.

To our knowledge, this cancer incidence cohort study specifically carried out in the pulp and paper industry is the first to report an increased risk for prostate cancer and skin melanoma. With respect to prostate cancer, data from previous mortality studies (11,12) and from a recent case-control study of 1516 incident prostate cancer cases (27) have shown similar relationships. Several chemicals to which pulp and paper workers may be exposed to have been associated with a risk of prostate cancer including cellulose and formaldehyde (24). Risk factors for skin melanoma are mainly related to skin constitution, intermittent sun exposure and propensity to sunburns (28); controlling for these factors was not possible in our study. Evidence for occupational risk factors in the pulp and paper industry has not been documented for skin melanoma in a large case-control study with exposure assessment (29), nor reported in cancer incidence studies carried out in this industry (15-17). The incidence rates of both prostate cancer and skin melanoma in British Columbia are significantly increased relative to Canadian rates (21) thereby raising the possibility of an overestimated risk in our study. We therefore re-analyzed our data using British Columbia cancer incidence rates. Relative risks for skin melanoma became reduced to non-significant levels, whereas the relative risk for prostate cancer remained significantly elevated among long term workers exposed to both Kraft and sulfite processes but not in the total cohort (data not shown). The decreased risks for developing cancer of the colon, bladder and lung cancer observed in this cohort when compared with the national rates, may be due to the fact that the BC rates for these cancers are lower than the national ones (21).

Differences between the results of the mortality and incidence cohorts were observed; in particular; the significantly increased risks from cancer of the esophagus (workers

employed in both Kraft and sulfite processes), kidney (all workers and workers employed in the Kraft process only) and brain (all workers) and from Hodgkin's disease (workers employed in the sulfite process only) among long term workers in the mortality cohort (1) were not confirmed in this incidence study. An in-depth look at the two sets of data, cancer mortality and incidence, identified likely reasons for most of the discrepancies noted. It must first be pointed out that, in Canada, national statistics are available from 1950 onwards for mortality and from 1969 onwards for cancer incidence, and that differences in mortality rates across Canada for the cancer sites referred to above are negligible (30). For Hodgkin's disease, a sub-analysis of the mortality data showed that the increased risk was confined to the period 1950-1968, with all three deaths among long term workers occurring during that time; thus, the cancer incidence results for the period 1969-1992, showing no excess risk concur with the mortality findings for the same time period.

Discrepancies between pathologic diagnosis of cancer and cause of death as listed on death certificates for cancers of the esophagus, kidney and brain range between 7 to 14 percent (31) and may be considerably higher (32). We reviewed the pathologic diagnosis of all long term workers who died from these three tumor sites between 1969 and 1992 in British Columbia and compared the diagnoses listed on the death certificates with those on the pathology reports obtained form the British Columbia Cancer Registry. There were 16 cases of death listed as esophageal cancer; of these, 6 cases (38%) were adenocarcinomas of the stomach on the pathology report. Thus, the statistically significant results for cancer of the esophagus noted in the mortality study were correctly attributed to stomach cancer based on more precise topography and morphology data.

Similarly, 4 of 18 cases (22%) of kidney cancer and 3 of 19 cases (16%) of brain cancer were attributed to other tumor sites on the pathology reports. Correcting the causes of death for these three cancer sites, resulted in non-significantly elevated *SMRs* levels for the 1969-1992 period.

In conclusion, the results of this cancer incidence study, in addition to documenting a risk of mesothelioma likely due to past asbestos exposure, point to a significant excess risk among long term workers in the pulp and paper industry for: 1) prostate and stomach cancers and all leukemias among workers employed in both Kraft and sulfite processes; 2) cancer of the rectum among workers employed in the sulfite process only. This study also indicates that precise diagnosis and the characteristics of mortality and cancer incidence databases need to be taken into consideration to accurately interpret results of occupational or environmental studies investigating cancer risks.

We are currently completing mill-specific and period-specific job exposure matrices (33) that will be used in a nested case-control study with detailed exposure assessment by job titles. That study should help to evaluate whether differences in chemical exposures among subset of workers might further explain the excess risk for specific cancers identified in our mortality and cancer incidence studies.

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Table 1. Cohort characteristics of the Cohort Cancer Incidence Study of Pulp and Paper Mill Workers, British Columbia, Canada, 1969-1992

Workers	No.	%	Person Years	%	Age at end of study (years) Mean	(SD)	Median	Years worked Mean	(SD)	Median	Worked in one mill (%)
Kraft only	20,041	70.9	323,476	68	47.0	(12.7)	46	11.1	(9.1)	8	96.0
Sulfite only	3,756	13.3	63,971	13	57.2	(15.8)	58	8.2	(8.8)	5	98.2
Ever employed in both kraft and sulfite mills	4,481	15.8	88,340	19	55.1	(13.2)	53	16.9	(13.2)	15	81.0
All	28,278		475,787		49.6	(13.9)	48	11.6	(10.1)	8	93.9

	No-cancer						Cancer						Total			
	Total		Active		Terminated		Total		Alive		Dead		Unknown Status		Traced	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Kraft Only	18,695	93.3	8,927	47.8	9,768	52.2	850	4.2	303	35.6	547	64.4	496	2.5	19,545	97.5
Sulfite Only	3,195	85.0	420	13.1	2,775	86.9	464	12.4	114	24.6	350	75.4	97	2.6	3,659	97.4
Ever employed in both kraft and sulfite mills	3,857	96.0	942	24.4	2,915	75.6	442	9.9	115	26.0	327	74.0	182	4.1	4,299	95.9
All	25,747	91.1	10,289	40.0	15,458	60.0	1,756	6.2	532	30.3	1224	69.7	775	2.7	27,503	97.3

* SD: Standard deviation

Table 2: Standardized incidence ratios (SIRs) for all cancers and cancer sites with 4 or more cases, by mill process and for all workers, Cohort Incidence Study of Pulp and Paper Mill Workers, British Columbia, Canada 1969-1992

Site		Kraft-Only			Sulfite-Only			Both Sulfite & Kraft			All Workers		
	ICD-9*	Obs*	SIR*	90%CI*	Obs	SIR	90%CI	Obs	SIR	90%CI	Obs	SIR	90%CI
All Cancer	140-172,174-208	850	0.91	0.86-0.96	464	1.17	1.08-1.26	442	1.05	0.97-1.13	1756	1.00	0.96-1.04
Tongue, Mouth & Pharynx	141,143-149	25	0.75	0.52-1.05	11	0.91	0.51-1.50	12	0.92	0.53-1.49	48	0.82	0.64-1.04
Esophagus	150	8	0.64	0.32-1.16	7	1.26	0.59-2.37	5	0.87	0.34-1.83	20	0.84	0.56-1.23
Stomach	151	34	0.95	0.70-1.27	17	0.94	0.60-1.41	27	1.52	1.07-2.09	78	1.09	0.89-1.31
Colon	153	68	0.90	0.73-1.10	34	0.98	0.72-1.30	30	0.83	0.60-1.13	132	0.90	0.78-1.04
Rectum	154	30	0.61	0.44-0.82	27	1.24	0.88-1.72	24	1.06	0.73-1.49	81	0.86	0.71-1.04
Liver	1550,1551	8	1.05	0.52-1.90	8	2.77	1.38-5.00	2			18	1.32	0.85-1.95
Gallbladder	156	2			2			4	1.57	0.53-3.58	8	0.78	0.39-1.40
Pancreas	157	16	0.64	0.40-0.97	21	1.77	1.19-2.55	12	0.99	0.57-1.60	49	1.00	0.78-1.27
Larynx	161	13	0.57	0.33-0.90	12	1.33	0.77-2.16	7	0.72	0.34-1.35	32	0.77	0.56-1.03
Lung	1622-1625,1628-1629	164	0.84	0.73-0.95	112	1.32	1.12-1.55	80	0.87	0.71-1.05	356	0.95	0.87-1.04
Pleura	163	5	1.78	0.70-3.74	3			2			10	2.05	1.11-3.47
Bone	170	3			0			1			4	0.69	0.23-1.57
Connective Tissue	1641,171	7	0.86	0.40-1.61	4	1.61	0.55-3.68	2			13	0.96	0.57-1.52
Skin Melanoma	172	45	1.55	1.19-1.99	10	1.39	0.75-2.35	17	1.87	1.19-2.81	72	1.59	1.29-1.93
Prostate	185	167	1.36	1.19-1.55	78	1.11	0.92-1.34	100	1.46	1.23-1.73	345	1.32	1.21-1.44
Testis	186	16	0.92	0.58-1.39	3			4	1.03	0.35-2.36	23	0.96	0.66-1.36
Kidney	1890,1,2	26	0.84	0.59-1.16	12	1.06	0.61-1.72	15	1.18	0.73-1.82	53	0.96	0.76-1.21
Bladder	188	41	0.73	0.55-0.95	23	0.87	0.59-1.23	15	0.55	0.34-0.85	79	0.72	0.59-0.87
Eye	190	6	2.12	0.92-4.18	1			1			8	1.61	0.80-2.91
Brain	191	23	0.99	0.68-1.41	10	1.53	0.83-2.59	10	1.24	0.67-2.10	43	1.14	0.87-1.47
Thyroid	193	8	1.06	0.53-1.92	3			3			14	1.21	0.73-1.89
Hodgkin's Disease	201	10	0.75	0.41-1.28	2			4	1.07	0.36-2.45	16	0.81	0.51-1.23
NHL*	200, 202	45	1.07	0.82-1.37	12	0.91	0.53-1.47	17	1.10	0.70-1.64	74	1.05	0.86-1.27
Multiple Myeloma	203	6	0.56	0.24-1.09	5	1.03	0.40-2.16	4	0.78	0.26-1.78	15	0.72	0.44-1.11
Lymphocytic Leukemia	204	10	0.83	0.45-1.41	7	1.34	0.63-2.51	7	1.28	0.60-2.40	24	1.06	0.73-1.49
Myeloid Leukemia	205	11	0.90	0.50-1.48	4	0.97	0.33-2.21	7	1.48	0.69-2.78	22	1.04	0.70-1.48
Leukemia	204-208	26	0.92	0.64-1.27	14	1.24	0.75-1.93	18	1.48	0.96-2.19	58	1.12	0.89-1.39

* ICD-9, *International Classification of Diseased*, Ninth Revision; Obs, observed number of cases; CI, confidence interval; NHL, non-Hodgkin's

Table 3: Latency analysis of all workers, Cohort Incidence Study of Pulp and Paper Mill Workers, British Columbia, Canada, 1969-1992

Cancer Site	ICD-9* Code	Time Since First Employed (Years)	Work Duration (Years)					
			<15			≥15		
			Obs*	SIR*	90% CI*	Obs	SIR	90% CI
All Cancer	140-172,174-208	<15	347	0.98	0.89 – 1.07	-	-	-
		≥15	685	1.13	1.06 – 1.21	724	0.91	0.86 – 0.97
Tongue, Mouth, & Pharynx	141, 143-149	<15	10	0.72	0.39 – 1.22	-	-	-
		≥15	28	1.37	0.97 – 1.88	10	0.41	0.22 – 0.70
Lung	162.2-5, 162.8-9	<15	49	0.76	0.59 – 0.96	-	-	-
		≥15	173	1.31	1.15 – 1.49	134	0.76	0.65 – 0.88
Pleura	163	<15	3	3.34	0.90 – 8.61	-	-	-
		≥15	1	0.54	0.02 – 2.57	6	2.80	1.22 – 5.52
Skin Melanoma	172	<15	20	1.25	0.83 – 1.82	-	-	-
		≥15	26	1.76	1.23 - 2.44	26	1.78	1.25 – 2.48
Prostate	185	<15	35	1.61	1.19 - 2.13	-	-	-
		≥15	135	1.38	1.19 – 1.59	175	1.24	1.09 – 1.40
Bladder	188	<15	19	0.94	0.62 - 1.38	-	-	-
		≥15	27	0.71	0.50 – 0.98	33	0.64	0.47 – 0.85
Colon	153	<15	30	1.16	0.84 - 1.57	-	-	-
		≥15	50	0.97	0.76 – 1.23	52	0.75	0.59 – 0.95

* ICD-9, International Classification of Diseases, Ninth Revision; Obs, observed number of cases; SIR, standardized incidence ratio; CI, confidence interval.

Table 4: Latency analysis of workers employed in the kraft process only, Cohort Incidence Study of Pulp and Paper Mill Workers, British Columbia, Canada, 1969-1992

Cancer Site	ICD-9* Code	Time Since First Employed (Years)	Work Duration (Years)					
			<15			≥15		
			Obs*	SIR*	90% CI*	Obs	SIR	90% CI
All Cancer	140-172,174-208	<15	271	0.95	0.86 – 1.05	-	-	-
		≥15	277	1.03	0.93 – 1.14	302	0.80	0.72 – 0.88
Tongue, Mouth, & Pharynx	141, 143-149	<15	7	0.62	0.29 – 1.17	-	-	-
		≥15	14	1.53	0.93 – 2.40	4	0.31	0.11 – 0.71
Rectum	154	<15	9	0.64	0.33 – 1.12	-	-	-
		≥15	8	0.55	0.27 – 0.99	13	0.62	0.37 – 0.99
Lung	162.2-5, 162.8-9	<15	41	0.78	0.59 – 1.02	-	-	-
		≥15	69	1.20	0.97 – 1.46	54	0.63	0.49 – 0.79
Skin Melanoma	172	<15	13	1.01	0.60 – 1.60	-	-	-
		≥15	17	2.29	1.46 – 3.43	15	1.73	1.06 – 2.66
Bladder	188	<15	14	0.87	0.52 – 1.35	-	-	-
		≥15	15	0.90	0.56 – 1.39	12	0.51	0.29 – 0.83

* ICD-9, International Classification of Diseases, Ninth Revision; Obs, observed number of cases; SIR, standardized incidence ratio; CI, confidence interval.

Table 5: Latency analysis of workers employed in the sulfite process only, Cohort Incidence Study of Pulp and Paper Mill Workers, British Columbia, Canada, 1969-1992

			Work Duration (Years)					
			<15			≥15		
Cancer Site	ICD-9* Code	Time Since First Employed (Years)	Obs*	SIR*	90% CI*	Obs	SIR	90% CI
Rectum	154	<15	1	0.72	0.03 – 3.42	-	-	-
		≥15	15	1.03	0.64 – 1.59	11	1.90	1.07 – 3.15
Skin Melanoma	172	<15	1	0.88	0.03 – 4.17	-	-	-
		≥15	6	1.21	0.53 – 2.39	3	2.65	0.72 – 6.85

* ICD-9, International Classification of Diseases, Ninth Revision; Obs, observed number of cases; SIR, standardized incidence ratio; CI, confidence interval.

Table 6: Latency analysis of workers ever employed in both kraft and sulfite processes, Cohort Incidence Study of Pulp and Paper Mill Workers, British Columbia, Canada, 1969-1992

			Work Duration (Years)					
			<15			≥15		
Cancer Site	ICD-9* Code	Time Since First Employed (Years)	Obs*	SIR*	90% CI*	Obs	SIR	90% CI
Stomach	151	<15	4	2.33	0.79 – 5.33	-	-	-
		≥15	2	0.77	0.13 – 2.43	21	1.55	1.04 – 2.24
Gallbladder	156	<15	-	-	-	-	-	-
		≥15	-	-	-	4	2.04	0.70 – 4.67
Skin Melanoma	172	<15	6	3.12	1.36 – 6.15	-	-	-
		≥15	3	1.25	0.34 – 3.23	8	1.68	0.84 – 3.03
Prostate	185	<15	2	1.06	0.18 – 3.34	-	-	-
		≥15	16	1.68	1.05 – 2.55	82	1.44	1.19 – 1.73
Bladder	188	<15	2	0.85	0.15 – 2.67	-	-	-
		≥15	1	0.24	0.01 – 1.12	12	0.58	0.33 – 0.94
Myeloid Leukemia	205	<15	2	2.33	0.40 – 7.31	-	-	-
		≥15	-	-	-	5	1.67	0.66 – 3.52
All Leukemia	204 - 208	<15	3	1.81	0.49 – 4.66	-	-	-
		≥15	1	0.49	0.02 – 2.30	14	1.66	1.00 – 2.59

* ICD-9, International Classification of Diseases, Ninth Revision; Obs, observed number of cases; SIR, standardized incidence ratio; CI, confidence interval.