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Version Post-Print/Accepted Manuscript

Citation Sritharan J*, Demers PA, Harris SA, Cole DC, Kreiger N, Sass-Kortsak
(published version) A, Lightfoot N. Natural resource based industries and prostate cancer risk in northeastern Ontario: a case control study. Accepted for publication in *Occupational and Environmental Medicine*, April 2016.

Publisher's Statement This article has been accepted for publication in the journal of *Occupational and Environmental Medicine* following peer review. The definitive copyedited, typeset version Sritharan J, Demers PA, Harris SA, et al. *Occup Environ Med* 2016;73:506–511 is available online at: <https://dx.doi.org/10.1136/oemed-2016-103573>.

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Natural resource based industries and prostate cancer risk in northeastern Ontario: a case-control study

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Key Words: occupational exposure; natural resource industries; prostate cancer

Word Count: 3,319

What this paper adds

- Exogenous factors may play a role in the etiology of prostate cancer, but there are still no well-established risks
- In previous studies, occupational exposures that have been evaluated in relation to prostate cancer resulted in mixed findings and many of these occupational exposures are found in natural resource based industry work
- In this study, elevated risks were observed for employment in forestry and logging industries, wood product industries, and paper and allied products industries and risks increased with ≥ 10 years duration of employment
- To further evaluate associations observed in this study, additional work should focus on natural resource based industry exposures in occupational groups

ABSTRACT

Objective Prostate cancer continues to be the most commonly diagnosed cancer in men, and there is limited knowledge on preventable risk factors. A number of occupational exposures in natural resource based industries are suspected to be related to prostate cancer risk. This study investigates associations between employment in these industries and prostate cancer.

Methods Data were from a population-based, case-control study previously conducted in Northeastern Ontario. Incident cases (N=760) aged 45-85 years who were diagnosed between 1995 and 1998 were identified from the Ontario Cancer Registry. Controls (N=1632) were recruited using telephone listings and were frequency-matched to cases by age. Lifetime occupational history was collected for all participants. Logistic regression was used to estimate odds ratios (OR) and their associated 95% confidence intervals (CI).

Results Elevated risks were observed for employment in forestry and logging industries (OR=1.87, 95% CI=1.32-2.73 and occupations (OR=1.71, 95% CI=1.24-2.35), and these risks increased with duration of employment for ≥ 10 years. Elevated risks were also found for employment in wood products industries (OR=1.45, 95% CI=1.07-1.97) and paper and allied products industries (OR=1.43, 95% CI=1.03-2.00) and when duration of employment was ≥ 10 years. There were also elevated risks in agriculture and mining related work, however these findings were not consistent across industry and occupation categories.

Conclusions Prostate cancer risk may be associated with work in several natural resource industries, primarily in the forest industries. To further evaluate observed associations, studies should focus on natural resource based exposures in larger populations with improved exposure assessment.

INTRODUCTION

Prostate cancer is the most commonly diagnosed cancer in North American and European men.¹⁻² The risk factors for prostate cancer are poorly understood with the exception of age, family history, and ethnicity.³⁻⁵ Exogenous factors may play a role in the etiology of prostate cancer, but there are still no well-established risks.^{1, 6} Occupational exposures (e.g., pesticides, metals, diesel exhaust, polycyclic aromatic hydrocarbons, and mineral oils) have been evaluated in relation to prostate cancer in previous studies with mixed findings.⁶⁻¹⁰ It is speculated that these occupational exposures may be related to prostate cancer risk but further research is necessary to strengthen the evidence. Many of these occupational exposures are commonly found in industries which involve the harvesting and extracting of raw materials from natural resources.¹¹ Many of these exposures have also been classified as known or probably carcinogenic to humans by the International Agency for Research on Cancer. Although there is limited physiologic evidence, these occupational exposures may be involved in impacting hormone levels leading to DNA damage and tumor initiation in the prostate.^{1, 7, 12} As the prostate is controlled by testosterone it is theorized that hormonal imbalances or androgenic stimulation may cause carcinogenesis as androgenic stimulation is important for promoting the growth of both normal and cancerous prostate cells. There is also evidence from human and animal studies that show high estrogen levels may lead to increased prostate cancer risk.^{7, 13-14} Androgenic stimulation and higher estrogen levels may be influenced by exposure to occupational, environmental, dietary and lifestyle factors.^{7, 12-14}

The current study utilizes data from a previously reported case-control study in Northeastern Ontario. Previous publications from this study primarily focused on potential risk factors unrelated to occupation, however one publication by Sass-Kortsak et al. addressed occupational factors related to prostate cancer.^{1, 12, 15-16} The paper reported on multiple potential exposures based on expert assessed cumulative lifetime exposure and identified a strong association for whole body vibrations and prostate

cancer. Sass-Kortsak et al. also found a significant association for employment in “trades, transport, equipment operators, and related occupations” and prostate cancer, however this was based on very broad occupation groups and longest held job.¹ Sass-Kortsak et al. did not explore detailed occupations and industries or duration of employment which is necessary for comparison to other studies in the literature. There is a need to build upon existing knowledge by evaluating risk using detailed information on occupation, industry, and exposures.

In Canada, primary industries include agriculture, forestry and logging, fishing and trapping, mining, and oil and gas extraction with a majority of workers being men.¹¹ The Northeastern region in the province of Ontario in Canada has a higher number of natural resource based workers than other parts of the country, primarily in the mining and forestry industries.¹¹ Major mining industries in Northeastern Ontario include uranium, gold, nickel, copper, and other metal mines. Risk of prostate cancer has not been studied exclusively in natural resource based industry workers, and since exposure levels to known and suspected carcinogens may be higher in these workers as compared to other occupational groups, it is important to conduct additional work. The objective of this study was to investigate potential associations between work in natural resource industries and occupations and the risk of prostate cancer in Northeastern Ontario. This study specifically focused on natural resource based exposures using detailed employment titles, duration of employment, and exposure to occupational agents that have not been examined in previous analyses of the data.

METHODS

Study Population

The case control study took place in Northeastern Ontario which represents a majority of the Northern Ontario population (~500,000) and included the regions of Sudbury, Algoma, Cochrane, Timiskaming,

Parry Sound, Muskoka, Manitoulin, and Sudbury District. The economy in Northern Ontario historically relied on natural resource based industries and these industries still remain as important contributors to economic growth in the region.¹⁷ The Sudbury region is recognized for its extensive development of copper and nickel mining, smelting, and refining processes and as a result Canada was a world leader in nickel production in the 1900s. Other metal discoveries included gold and silver deposits that spanned across Northeastern Ontario and included the regions of Cobalt, Porcupine Lake, Timmins, and Kirkland Lake. In the 1950s, Elliot Lake in the Algoma District became a booming area for uranium mining.¹⁷ The forestry and wood industries were primarily sawmill and pulp and paper mills and in 2004 at least one third of Northern Ontario was dependent on the forestry industry.¹⁸ Farming and agriculture has continued in multiple regions across Northern Ontario, including Timiskaming, Cochrane, Sudbury, Parry Sound, Algoma, and Manitoulin and production is expected to increase by 20 to 50% in the coming years.¹⁹

As this was a secondary analysis of a previously conducted study, the detailed description of the study sample can be found in previously published papers.^{1, 16, 20-21} Briefly, incident prostate cancer cases were men between the ages of 45 to 85 years, who resided in Northeastern Ontario, and were identified in the Ontario Cancer Registry with primary histologically confirmed prostate cancer diagnosed between January 1995 and December 1998. Controls were randomly selected from the Northeastern Ontario population using residential telephone listings and were frequency matched 2:1 to cases based on 5 year age groups. Participation rates in the study were 73.6% for cases and 47.5% for controls.²⁰

Exposure Classification

Consenting participants were mailed a questionnaire followed by telephone contact by trained interviewers. The questionnaire included sections on demographics, general health, smoking, diet,

physical activity, family, and occupational history. Interviewers utilized the questionnaire to assess detailed lifetime job histories based on jobs held for 1 or more years. Each job history included information on job titles, employer name and type, job duties, work description, and work environment.^{1, 16, 20} An occupational hygienist coded job descriptions (four digit) using the 1991 Standard Occupation Classification (SOC91) and 1980 Standard Industry Classification (SIC80) systems.²²⁻²³ Industries and occupations were then broadly grouped into 58 new occupation categories and 38 new industry categories based on their SOC91 and SIC80 codes²²⁻²³ and similarities in job tasks and potential exposures. For this current analysis only industries and occupations related to natural resources were included, resulting in 10 industry and 9 occupation categories (Table 1, Supplementary File). Ever employment was defined as any job held for at least one year with corresponding SOC91 and SIC80 codes. Duration of employment was examined by categorizing employment as less than 10 years and 10 years or greater to assess short term and long term exposures. Potential exposure response trends in duration of employment and prostate cancer risk were also examined using tertile categories, based on the distribution of controls in each industry and occupation. Self-reported data were also used to assess ever versus never exposure in cases and controls based on participant responses to occupational agents listed in the questionnaire.

Statistical Analysis

Unconditional logistic regression models were used to assess if duration of employment in different natural resource industries and occupations, and if relevant occupational exposures, were associated with prostate cancer. All cases or controls not employed in the specific category being evaluated served as the non-exposed referent category. Only categories with at least 5 cases or 5 controls were analyzed. SAS version 9.2 was used for statistical modelling.²⁴ Odds ratios with 95% confidence intervals above 1 were considered statistically significant. Adjustments were made for five year age groups and family

history of prostate cancer. Ethnicity was not included as a covariate as the majority of participants were Caucasian.^{1, 16, 20} Education and income were considered as potential confounders however these factors did not present any significant changes in the odds ratios. History of venereal disease and cumulative lifetime occupational physical activity were found to be significant in previous publications, but adjusting for these variables resulted in no significant changes in our estimates.^{1, 20} Exposure response trends were evaluated using logistic regression by treating the ordinal variables as continuous in the model to calculate the p-values for trend. Additionally, industries and occupations in this study that were previously associated with prostate cancer in the literature (i.e., farming and agriculture) were also reported and discussed.

RESULTS

Cases and controls were of similar age (mean 68.2 years, SD=7.5) (Table 1). Of the potential covariates examined, only family history of prostate cancer was significantly associated with prostate cancer risk (OR 2.85, 95% CI 2.13-3.83). All subsequent analyses by industry group (Table 2) and occupation group (Table 3) were adjusted for both age and family history.

Table 1. Selected characteristics of cases and controls in the Northeastern Ontario Prostate Cancer Study

	Cases (N=749) (%)	Controls (N=1608) (%)	OR* (95%)
AGE GROUPS (YEARS)			
45 to <50	8 (1.1)	18 (1.1)	
50 to <55	25 (3.3)	68 (4.2)	
55 to <60	48 (6.4)	135 (8.4)	
60 to <65	133 (17.7)	271 (16.8)	
65 to <70	220 (29.0)	439 (27.3)	
70 to <75	177 (23.63)	381 (23.69)	
75 to <80	106 (14.1)	198 (12.3)	
80 to <85	31 (4.1)	95 (5.9)	
Missing	1 (0.1)	3 (0.2)	
FAMILY HISTORY OF PROSTATE CANCER			
Yes	108 (14.4)	90 (5.6)	2.83 (2.10-3.80)
No	641 (85.6)	1519 (94.4)	Ref
ETHNICITY			
English Canadian	402 (53.7)	901 (56.0)	0.98 (0.79-1.22)
French Canadian	173 (23.1)	332 (20.7)	1.15 (0.89-1.50)
Aboriginal (Native)	7 (0.9)	6 (0.4)	2.69 (0.89-8.18)
Other	165 (22.0)	361 (22.5)	Ref
Missing	2 (0.3)	8 (0.5)	0.56 (0.12-2.67)
EDUCATION			
No school	2 (0.3)	3 (0.2)	1.29 (0.21-7.87)
Some elementary	99 (13.2)	188 (11.7)	Ref
Elementary	158 (21.1)	341 (21.2)	0.87 (0.64-1.18)
Some high school	226 (30.2)	415 (25.8)	1.04 (0.77-1.39)
Finished high school	138 (18.4)	319 (19.8)	0.83 (0.60-1.14)
Some college/university	32 (4.3)	84 (5.2)	0.73 (0.45-1.17)
Finished college/university	67 (9.0)	189 (11.8)	0.68 (0.47-0.99)
Post graduate	17 (2.3)	43 (2.7)	0.78 (0.42-1.44)
Professional	5 (0.7)	17 (1.1)	0.56 (0.20-1.57)
Missing	5 (0.7)	10 (0.6)	1.03 (0.34-3.2)
TOTAL FAMILY INCOME			
<\$20,000	94 (12.6)	183 (11.4)	Ref
\$20,000-\$39,000	269 (35.9)	517 (32.1)	0.97 (0.72-1.30)
\$40,000-59,000	178 (23.8)	455 (28.3)	0.72 (0.52-0.98)
\$60,000-\$79,000	87 (11.6)	171 (10.6)	0.97 (0.66-1.41)
\$80,000-\$99,999	28 (3.7)	55 (3.4)	0.97 (0.57-1.65)
>\$100,000	21 (2.8)	59 (3.7)	0.69 (0.39-1.21)
Missing	72 (9.6)	168 (10.5)	0.80 (0.55-1.16)

*adjusted for age

A non-significantly elevated risk was observed for employment in the agricultural industry (agriculture and farm work, and services incidental to agriculture) (OR 1.15, 95% CI 0.96-1.38). Fishing and trapping industry work demonstrated an elevated risk (OR 3.32, 95% CI 1.14-9.67), which was highest for those employed for <10 years (OR 4.49, 95% CI 1.05-19.17). For employment in the forestry and logging industry, there was an elevated risk (OR 1.87, 95% CI 1.32-2.73), which was highest for employment ≥ 10 years (OR 2.55, 95% CI 1.59-4.11) and a significant trend was observed with duration of employment ($p_{\text{trend}} < 0.0001$). An elevated risk was observed for employment in the wood products industry (OR 1.45, 95% CI 1.07-1.97), which somewhat increased with ≥ 10 years duration of employment (OR 1.73, 95% CI 1.08-1.90). A significant increasing trend was also observed for employment in the wood products industry ($p_{\text{trend}} = 0.011$). There was an elevated risk for employment in the paper and allied products industry (OR 1.43, 95% CI 1.03-2.00), especially with ≥ 10 years of employment (OR 1.98, 95% CI 1.29-3.02) and a significant trend was observed ($p_{\text{trend}} = 0.007$). For the mining industry, there was an elevated risk for employment in other services incidental to mining (OR 2.09, 95% CI 1.18-3.72) and a non-significantly elevated risk with ≥ 10 years of employment duration (OR 2.50, 95% CI 0.90-7.00). A significant trend for duration of employment was also observed for these mining related workers ($p_{\text{trend}} = 0.004$). A non-significantly elevated risk was observed for employment in the quarrying industry (OR 3.33, 95% CI 0.76-14.54) however, due to the small sample size, a trend analysis could not be performed. There were no strong associations observed for employment in metal mining, non-metal mining, and petroleum and coal mining industries.

Table 2. Odds ratios and 95% CIs for associations between prostate cancer and employment in natural resource based industries

Industry Groups	Duration					
	>0 to <10 Years			≥10 Years		
	Cases/ Controls	OR* (95% CI)	Cases/ Controls	OR* (95% CI)	Cases/ Controls	OR* (95% CI)
Agriculture and Farm Work, Services Incidental to Agriculture	276/531	1.15 (0.96-1.38)	92/159	1.29 (0.97-1.71)	184/372	1.10 (0.89-1.35)
Forestry and Logging	60/68	1.90 (1.32-2.73)	33/45	1.51 (0.94-2.40)	27/23	2.70 (1.52-4.79)
Fishing and Trapping	8/6	3.32 (1.14-9.67)	5/3	4.49 (1.05-19.17)	3/3	2.25 (0.45-11.22)
Metal Mining	202/460	0.96 (0.79-1.17)	71/137	1.15 (0.85-1.57)	131/323	0.88 (0.85-1.57)
Non Metal Mining	12/28	0.90 (0.45-1.80)	8/21	0.77 (0.33-1.76)	4/7	1.34 (0.39-4.66)
Quarrying	5/3	3.33 (0.76-14.54)	3/3	2.08 (0.40-10.68)	2/0	--
Petroleum and Coal	3/11	0.62 (0.17-2.24)	3/8	0.80 (0.21-3.07)	0/3	--
Other Services Incidental to Mining	24/25	2.09 (1.18-3.72)	16/18	1.94 (0.97-3.86)	8/7	2.50 (0.90-7.00)
Wood Products	79/120	1.45 (1.07-1.97)	46/77	1.30 (0.88-1.90)	33/43	1.73 (1.08-1.90)
Paper and Allied Products	62/99	1.43 (1.03-2.00)	20/49	0.90 (0.53-1.53)	42/50	1.98 (1.29-3.02)

*adjusted for age and family history of prostate cancer

At an occupation level, there was an elevated risk for general farm workers and labourers (OR 1.23, 95% CI 1.02-1.49) which was higher for those employed <10 years (OR 1.42, 95% CI 1.06-1.91). No significant trends were identified for duration of employment in agriculture and farm work. A non-significantly elevated risk was found for occupations related to fishing, trapping, and hunting (OR 3.03, 95% CI 0.91-10.06). No trend analysis was performed on this group due to its small sample size. Elevated risks were also observed for forestry and logging occupations (OR 1.71 95% CI 1.24-2.35), which was highest for duration of employment of ≥10 years (OR 2.55, 95% CI 1.58-4.11). A significant trend with duration of employment was observed for forestry and logging ($p_{\text{trend}} < 0.0001$). For wood processing and making occupations, the risk was not elevated (OR 1.16, 95% CI 0.86-1.57). An elevated risk was observed for men employed in wood processing and making occupations within the wood industry (OR 1.64, 95% CI 1.06-2.54), although an excess was also observed among non-wood-related occupations in the same industry (OR 1.45, 95% CI 1.07-1.97). There were no strong associations observed for employment in pulp and papermaking occupations and mining related occupations.

Table 3. Odds ratios and 95% CIs for associations between prostate cancer and employment in natural resource based *occupations*

Occupation Groups	Cases/ Controls	OR* (95% CI)	Cases/ Controls	Duration		Cases/ Controls	OR* (95% CI)
				>0 to <10 Years			
Farmers, Farm and Agriculture Managers	48/128	0.74 (0.52-1.05)	12/39	0.59 (0.30-1.14)		36/89	0.81 (0.54-1.22)
General Farm Workers and Labourers	243/443	1.23 (1.02-1.49)	84/134	1.42 (1.06-1.91)		159/309	1.15 (0.92-1.44)
Agriculturists and Related Specialists	3/8	0.79 (0.21-3.03)	2/0	--		1/8	0.25 (0.03-2.08)
Forestry and Logging	75/97	1.71 (1.24-2.35)	37/63	1.26 (0.83-1.93)		38/34	2.55 (1.59-4.11)
Fishing, Trapping, and Hunting	6/5	3.02 (0.91-10.03)	4/3	3.65 (0.80-16.67)		2/2	2.18 (0.31-15.55)
Mining, Quarrying, Oil, and Gas	149/297	1.12 (0.89-1.39)	64/115	1.21 (0.88-1.68)		85/182	1.05 (0.80-1.39)
Wood Processing and Making	76/139	1.16 (0.86-1.57)	27/60	0.94 (0.58-1.50)		49/79	1.33 (0.92-1.93)
Pulp and Papermaking	28/47	1.32 (0.82-2.14)	18/34	1.17 (0.65-2.09)		10/13	1.75 (0.76-4.05)
Primary Production and Manufacturing Managers	21/44	1.05 (0.61-1.78)	5/14	0.77 (0.27-1.16)		16/30	1.18 (0.63-2.20)

*adjusted for age and family history of prostate cancer

For self-reported occupational exposures, a number of exposures presented non-significantly elevated odds ratios (Table 2, Supplementary File).

DISCUSSION

This study reports on multiple strong associations and trends between employment in natural resource industries and occupations and prostate cancer risk. These results provide additional evidence on the potential occupational risk factors for prostate cancer in an area where natural resource-based employment is concentrated.

In our study, a small overall increase among agricultural workers was observed. The excess appeared to be restricted to farm workers and labourers with the highest risk among those employed for less than 10 years. Previous studies have been conducted to investigate the relationship between prostate cancer

and agriculture related occupations with inconsistent findings.²⁵⁻²⁹ Prostate cancer in relation to agriculture and farming occupations has been more commonly studied than other occupations with most studies focused on pesticide exposures. A meta-analysis that looked at the association between farming and prostate cancer found a nearly four-fold increased risk overall (OR 3.83, 95% CI 1.96-7.48) but found an inverse association between pesticide exposure and prostate cancer.²⁶ A recently published study of prostate cancer in a rural population in Saskatchewan, Canada identified that combined workplace exposure to insecticides and fungicides was significantly associated with prostate cancer (OR 2.23, 95% CI 1.15-4.33).³⁰ Specific organophosphate insecticides such as fonofos, malathion, terbufos, and aldrin have been associated with aggressive prostate cancer.³¹ Other studies have found pesticide exposure from farming occupations to be a possible risk factor for prostate cancer.^{7, 32} Specifically, pesticide applicators with exposure to chlorinated pesticides and methyl bromide were linked to increased prostate cancer risk ($p=0.005$).³³ There is evidence that insecticides, herbicides and metal (e.g. cadmium) exposures are linked to prostate cancer risk.^{30, 34}

In 2013, a report was published on the use of 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) herbicide in Ontario and the possible health effects.³⁵ From the early 1940s to late 1970s, chemical agents like 2,4,5 T were utilized to aid in the re-establishment of the conifer forest in Northern Ontario. This herbicide is classified as a possible carcinogen (group 2B) by IARC (likely due to its contamination with 2,3,7,8-TCDD, a carcinogenic dioxin) and is linked to prostate cancer with limited evidence.³⁵ Given that the time period of occupational use of this herbicide overlaps with the work records of the study cases, it is likely that Northern Ontario agricultural workers were exposed to 2,4,5 T and the associated dioxin contaminants. The interpretation of these important findings across different studies continues to be inconsistent. But the existence of an excess risk in agriculture and farming related occupations demonstrates the need for further research.

Employment in fishing and trapping was also found to be associated with prostate cancer risk in this study, however the number of exposed workers was quite small and the confidence intervals were wide. The strongest associations were observed for work <10 years. It is unclear what type of exposures in fishing and trapping work could contribute to the risk of prostate cancer.

Employment in forestry and logging in this case control study was found to be associated with prostate cancer, especially among those employed for greater than 10 years. Based on an analysis of tertile categories, employment in forestry and logging at both an occupation and industry level demonstrated a significant trend with duration of employment. Employment in this occupation included work as forestry and logging professionals, operators, and labourers. Forestry and logging operations involve use of heavy machinery and equipment that may lead to exposure of diesel exhaust, wood dust and whole body vibrations.^{1, 36} There are few studies that examine forestry and logging related exposures, and currently there are no studies that examine prostate cancer. It is also unclear how the interaction of these exposures contributes to the risk of prostate cancer.

Employment in the wood products industry was also associated with prostate cancer and the risk increased with ≥ 10 years duration. An excess was observed among men in both wood-related and non-wood-related occupations within the wood products industry. This may indicate that the risk in the wood products industries are due to exposures unique to that industry, rather than woodworking itself. The wood industries include sawmills and planing mills, as well as other wood product industries where there may be exposure to the volatile components of fresh wood as well as pesticides, such as fungicides and wood preservatives. Employment in the paper and allied products industry was also associated with prostate cancer, especially with ≥ 10 years duration and a significant trend was observed with duration of employment. At an occupational level, the specific group of pulp and papermaking

occupations had no increased risk. Primarily, exposure in the wood products and paper industries include wood dust and wood pulping and papermaking chemicals such as sulphates and chlorine compounds.³⁷⁻³⁹ These chemical exposures in forestry, wood products, and paper industries may act as endocrine disruptors in the human body.³⁹ These disruptors could influence hormone levels and play a role in prostate cancer etiology.⁷

At an industry level, metal mining, non-metal mining, quarrying, and petroleum and oil industries were not found to be associated with prostate cancer. However, employment in other services incidental to mining was found to be associated with prostate cancer and increased with duration. This group included contract drilling and any other services related to mining. It is unclear as to what other specific services were included in this group but there may be a heterogeneous combination of mining jobs. At an occupation level, mining related work was not found to be associated with prostate cancer. Employment in mining can result in many different exposures depending on the type of mining (surface vs. underground) and the substance being mined. Other studies have identified multiple exposures in mining including but not limited to metals, dust, diesel exhaust, whole body vibrations, radiation, shift work, and other chemicals.⁴⁰⁻⁴¹

As a part of the original study, participants were asked in the study questionnaire to report if they were ever exposed to listed occupational agents. Based on these self-reported data, an elevated risk was observed for sun exposure and non-significantly elevated risks were observed for exposure to diesel exhaust, pesticides, combustion products, lubricating oils, and noise. (Table 2, Supplementary File). Although the ever/never exposure classifications represents unadjusted associations and are self-reported, these findings may provide further evidence on specific agents related to natural resource based work.

This study has a number of limitations based on data collection and approach. The response rate of cases and controls were lower than desired and recall bias may be a factor with questionnaires provided to both cases and controls.^{16, 20} Not unexpectedly, the response rate of controls was much lower than for cases such that selection bias could occur while also making the results less generalizable to the population. Some industry and occupation categories also presented small sample sizes. This study relied on job titles and even though similar exposure jobs were grouped together there is still room for heterogeneity as significant findings in sub-sector groups may be diluted and not detected in these broader level categories. There was also no information collected on the stage or aggressiveness of the tumors in cases which may have been useful to examine occupational exposure differences by aggressiveness of prostate cancer. This study also has a number of strengths. The availability of lifetime job histories provided useful detailed job information for this specific region with a high prevalence of natural resource industry work. This study also collected data on three known risk factors for prostate cancer, age, family history, and ethnicity, which have not always been available in other prostate cancer studies.

CONCLUSION

This study offers additional evidence that employment in natural resource based industries and occupations may be associated with a higher risk of prostate cancer. Specifically, long-term employment in forestry, logging, wood, and the paper industry was observed to be associated with increased risks of prostate cancer. Additional elevated risks were observed for other natural resource based industries and occupations. Although there were no clear occupational agents identified, workers in these industries are exposed to multiple known and suspected carcinogens that are important to assess in further analyses. Use of detailed exposure data in larger study populations is needed to further evaluate the

potential role of occupational exposures in the development of prostate cancer.

ACKNOWLEDGEMENTS

Jeavana Sritharan is supported through funding from the Canadian Cancer Society. The Occupational Cancer Research Centre is funded by the Canadian Cancer Society Research Institute, the Ontario Ministry of Labour, and Cancer Care Ontario. Manisha Pahwa is also thanked for her contribution to data analysis and manuscript preparation.

COMPETING INTERESTS: None

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Contributorship Statement

The corresponding author, Jeavana Sritharan, is the main contributor to this secondary analysis and was the main contributor in planning and designing the research analysis, conducting the analysis, and reporting and interpreting the work into a manuscript. Dr. Paul A Demers, Dr. Shelley Harris, and Dr. Donald Cole contributed to the planning and design of the analysis, reporting and interpretation of the work, and review of the analysis and manuscript. Dr. Nancy Kreiger, Dr. Andrea Sass-Kortsak and Dr. Nancy Lightfoot contributed to the planning, conducting, and reporting of the original case-control study (primary analysis) and were a part of the planning of analysis, reporting and interpretation of the work, and manuscript preparation. Manisha Pahwa is mentioned in the acknowledgements section for her contribution to planning the analysis and manuscript preparation.

Ethics Statement

This research received ethics review and approval from the Laurentian Hospital Research Ethics Board in Sudbury, Ontario, Canada prior to 1995 when the study was initiated. Consent was obtained from cases and controls prior to participation in the study.

Previous publication related to this manuscript

Sass-Kortsak MA, Purdham JT, Kreiger N, et al. Occupational risk factors for prostate cancer. *American Journal of Industrial Medicine* 2007;50: 568-576.