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Cancer risk among firefighters and police in the Ontario workforce

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ABSTRACT

Objective Firefighters and police often work in high-stress, complex environments with known and suspected carcinogenic exposures. We aimed to characterise cancer incidence among firefighters and police.

Methods The Occupational Disease Surveillance System (ODSS) was used to identify workers employed as firefighters or police in Ontario. A cohort of workers were identified using lost-time workers' compensation claims data and followed for cancer in the Ontario Cancer Registry (1983–2020). Cox proportional hazard models were used to estimate HRs and 95% CIs for primary site-specific cancer diagnoses adjusted for age at start of follow-up, birth year and sex.

Results A total of 13 642 firefighters and 22 595 police were identified in the cohort. Compared with all other workers in the ODSS, firefighters and police had increased risk of prostate cancer (firefighters: HR=1.43, 95% CI 1.31 to 1.57; police: HR=1.47, 95% CI 1.35 to 1.59), colon cancer (firefighters: HR=1.39, 95% CI 1.19 to 1.63; police: HR=1.39, 95% CI 1.21 to 1.60) and skin melanoma (firefighters: HR=2.38, 95% CI 1.99 to 2.84; police: HR=2.27, 95% CI 1.96 to 2.62). Firefighters also had increased risk of cancer of the pancreas, testis and kidney, as well as non-Hodgkin's lymphoma and leukaemia. Police had increased risk of thyroid, bladder and female breast cancer. When compared directly with the police, firefighters had an elevated risk of mesothelioma and testicular cancer.

Conclusions Firefighters and police demonstrated some similar as well as some unique cancer risks. Findings from this larger worker population may have important implications for workplace and policy-level changes to improve preventative measures and reduce potential exposures to known carcinogenic hazards.

Key messages

What is already known about this subject?

⇒ Firefighters and police are recognised as high-risk occupations.
⇒ While there are many existing studies on risk of cancer among firefighters, there are fewer studies on risk of cancer among the police and findings remain inconsistent for both.

What are the new findings?

⇒ Our study provides findings on a large worker cohort, identifying increased risk of cancers among firefighters and police.
⇒ Our findings support those of previous studies and provide evidence of increased risk of other cancer sites with previously limited evidence.
⇒ Firefighters and police had increased risk of cancer of the prostate and colon and of melanoma.
⇒ Additionally, firefighters had increased risk of pancreatic, testicular and kidney cancer, and non-Hodgkin's lymphoma and leukaemia, while police had increased risk of thyroid, bladder and female breast cancer.

How might this impact on policy or clinical practice in the foreseeable future?

⇒ The identified consistent risk of cancer among firefighters and police may reflect the unique risk factors of each profession or, in some cases, shared risk factors.
⇒ Gaining a better understanding of the risk of cancer and related exposures can help to determine appropriate preventative measures for firefighters and police.

INTRODUCTION

Protective service occupations (firefighters and police) provide 24-hour service in inherently dangerous environments that may include exposure to known or suspected carcinogens. Firefighters may be exposed to both fire-related (eg, heavy metals, polycyclic aromatic hydrocarbon (PAH)) and non-fire-related (eg, shiftwork, diesel engine exhaust (DEE)) carcinogens.[1] Police may be exposed to shiftwork and engine exhaust during their job.[1–3] These exposures may increase their risk of developing cancer.

In 2010, the International Agency for Research on Cancer (IARC) classified firefighting as possibly carcinogenic to humans (group 2B) based on evidence with prostate and testicular cancer and non-Hodgkin's lymphoma (NHL).[1] A meta-analysis by Jalilian *et al*[4] identified an elevated risk of colon, rectal, prostate, testicular, bladder and thyroid cancers, as well as mesothelioma and melanoma, among firefighters.[4] A recent Norwegian fire departments cohort observed associations for urinary and laryngeal cancer and mesothelioma.[5]

A systematic review of 14 studies by Wirth *et al*[6] showed risk of different cancer sites with mixed

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findings, and the strongest evidence seemed to be for all cancers, colon and digestive system cancers, and Hodgkin's lymphoma.[6] A recent study of male Canadian police supports a potential increased risk of all cancers and colon cancer and reported significantly increased risk of melanoma and male breast and prostate cancer.[7] Recent studies also show an increase in prostate cancer.[1 2 8]

Although there are many studies reporting on cancer risk among firefighters, fewer are available among the police. Furthermore, many of the suspected cancers have low case fatality rates and few studies reported on cancer incidence. Lastly, firefighters and police have strict physical fitness requirements at hire, which may bias the results as most studies used the general population as a comparison group. For firefighters, a priori cancer sites of interest, identified by the IARC, include prostate and testicular cancer and NHL.[1] For the police, a priori sites of interest based on findings from Wirth *et al*[6] include colon and Hodgkin's lymphoma.[6] The objective of this study was to examine cancer incidence among firefighters and police, compared with one another and compared with all other workers in the cohort.

METHODS

The Occupational Disease Surveillance System (ODSS) was established to monitor work-related disease among Ontario workers by linking large, administrative health databases. The ODSS was created from accepted lost-time workers' compensation injury and disease claims from the Workplace Safety and Insurance Board (WSIB), which covers approximately 70%–75% of Ontario workers.[9] Occupation and industry were coded by the WSIB using the 1971 Canadian Classification Dictionary of Occupation (CCDO) and the 1970 and 1980 Standard Industrial Classification. Claimants (n=2 387 756) from 1983 to 2019 were eligible for linkage to the Registered Persons Database (RPDB). Claimants <15 years old or with missing sex, birthdate, claim date, occupation and industry information were excluded (n=17 557).

The RPDB provides information on sex, birthdate, death date and residence, including emigration out of Ontario, prior to or during follow-up.[9] By use of the health insurance number (HIN), a unique identifier for individuals registered for insured health services, 1 964 519 workers were linked to the RPDB. The remaining workers who did not have HIN (n=405 680) were linked using probabilistic linkages (use of name, sex, birthdate, death date) and 1973 workers were not linked due to missing information. A total of 2 368 226 workers were included in the cohort.

The Ontario Cancer Registry (OCR) includes incident cases of malignant cancer diagnoses (1964–2020). The registry's data come from regional cancer centres (largest source), hospital discharge/day surgery records and hospital/laboratory pathology reports. WSIB records were linked to the OCR through deterministic and probabilistic linkages. Cases with a diagnosis date prior to entry into the cohort (1 January 1983) were excluded as these were considered prevalent cases (n=197 927). Claimants who entered the cohort for a cancer claim were also excluded. For example, a firefighter with a presumptive cancer would be more likely to already be in the WSIB data, which may bias the study; thus, these claimants were excluded at baseline. Incident cancer cases were coded using the International Classification of Diseases 10th Revision.

Table 1 Descriptive characteristics of firefighters and police officers in the ODSS cohort, 1983–2020

	CCDO 6111 Firefighters	CCDO 6112 Police officers	ODSS cohort
Total, n	13 642	22 595	2 368 226
Major industry group, n			
Federal	259	333	34 596
Provincial	841	6263	46 531
Municipal	11 376	17 383	118 008
Male, %	96	83	65
Year of birth, median (IQR)	1958 (1949–1968)	1964 (1953–1973)	1960 (1950–1970)
Years of follow-up, median (IQR)	21 (11–30)	20 (10–30)	23 (12–31)
Age at start of follow-up, median (IQR), years	38 (32–45)	34 (29–42)	34 (25–45)
Age at end of follow-up, median (IQR), years	59 (50–68)	55 (46–65)	58 (49–68)

CCDO, Canadian Classification Dictionary of Occupation; IQR, Interquartile Range; n, number of workers; ODSS, Occupational Disease Surveillance System.

Statistical analyses

Workers were followed from the date of their first WSIB-accepted compensation claim to the earliest of their first cancer diagnosis date, emigration out of Ontario, age 85 years, death or study end (31 December 2020). We identified claims coded as CCDO 6111 'firefighting occupations' and CCDO 6112 'police officers and detectives (government)'. Cox proportional hazard regression models were used to estimate HRs and corresponding 95% CIs for site-specific cancer diagnoses among firefighters and police, compared with all other workers in the ODSS. Models comparing firefighters with the police and vice versa were used to reduce potential selection bias due to the strict entry requirements for both professions and confounding by lifestyle or occupational exposures that may be observed when comparing with all other workers. Models were adjusted for age at start of follow-up (continuous), birth year (continuous) and sex (binary).

Statistical analysis was performed using SAS V.9.4. The final data set was de-identified to ensure inability of identifying individuals either alone or with other health information.

RESULTS

The ODSS cohort includes 13 642 firefighters and 22 595 police officers and detectives. The characteristics of the cohort are provided in table 1, stratified by occupation. Police officers were younger and had more women than firefighters.

Table 2 presents adjusted HRs, stratified by occupation. Both occupations showed statistically significant increased risk of diagnosis of any cancer, prostate and colon cancer, and melanoma of the skin. Firefighters also had statistically significant associations for pancreatic, kidney and testicular cancer, as well as NHL and leukaemia. When examining leukaemia by subtype among firefighters, we observed a statistically significant increased risk of chronic lymphocytic leukaemia (CLL) (HR=1.81, 95% CI 1.31 to 1.51). The case count was unreportable (<6) for acute lymphocytic leukaemia (ALL), and there was no association for chronic myeloid leukaemia and acute myeloid leukaemia (AML). Non-statistically significant excess for cancers of the rectum, brain and bladder was also observed among firefighters (lower confidence interval (LCL) >0.9). The police had statistically significant associations for thyroid, bladder and female breast cancer. The police also had non-statistically significant

Table 2 HR and corresponding 95% CI for firefighters and police compared with all other workers in the ODSS cohort, 1983–2020

		Firefighters (n=13 642)		Police (n=22 595)	
ICD-10 code	Cancer site	Cases (n)	HR* (95% CI)	Cases (n)	HR* (95% CI)
C0–C97	Any cancer	1730	**1.23 (1.17 to 1.29)**	2377	**1.17 (1.13 to 1.22)**
C00	Lip	11	1.61 (0.89 to 2.92)	11	1.17 (0.65 to 2.13)
C01–C14	Oral	56	1.10 (0.84 to 1.43)	79	1.10 (0.88 to 1.37)
C15	Oesophagus	29	1.06 (0.73 to 1.53)	43	1.17 (0.86 to 1.58)
C16	Stomach	34	0.78 (0.55 to 1.09)	57	0.97 (0.75 to 1.27)
C18	Colon	152	**1.39 (1.19 to 1.63)**	203	**1.39 (1.21 to 1.60)**
C20	Rectum	66	1.18 (0.93 to 1.51)	76	0.98 (0.78 to 1.23)
C22	Liver	25	0.72 (0.49 to 1.07)	36	0.75 (0.54 to 1.04)
C25	Pancreas	53	**1.34 (1.02 to 1.76)**	63	1.15 (0.90 to 1.47)
C30	Nasal	<6		<6	
C32	Larynx	15	0.68 (0.41 to 1.13)	18	*0.61 (0.39 to 0.97)*
C34	Lung	210	*0.84 (0.74 to 0.97)*	237	*0.71 (0.62 to 0.80)*
C45	Mesothelioma	11	1.56 (0.86 to 2.84)	<6	
C40	Bone	<6		15	1.24 (0.75 to 2.07)
C43	Melanoma	125	**2.38 (1.99 to 2.84)**	184	**2.27 (1.96 to 2.62)**
C50	Breast (female)	7	0.97 (0.46 to 2.03)	80	**1.26 (1.01 to 1.57)**
C50	Breast (male)	<6		8	1.20 (0.60 to 2.42)
C53	Cervix	<6		12	1.56 (0.88 to 2.75)
C56	Ovary	<6		9	1.01 (0.53 to 1.95)
C61	Prostate	492	**1.43 (1.31 to 1.57)**	623	**1.47 (1.35 to 1.59)**
C62	Testis	30	**2.56 (1.78 to 3.68)**	29	1.31 (0.91 to 1.89)
C64	Kidney	94	**1.52 (1.24 to 1.87)**	97	1.08 (0.88 to 1.31)
C67	Bladder	120	1.15 (0.96 to 1.37)	169	**1.25 (1.07 to 1.45)**
C69	Eye	<6		8	1.22 (0.61 to 2.46)
C71	Brain	37	1.26 (0.91 to 1.74)	53	1.17 (0.89 to 1.53)
C73	Thyroid	27	1.11 (0.76 to 1.62)	72	**1.35 (1.07 to 1.70)**
C81	Hodgkin's lymphoma	10	1.27 (0.68 to 2.37)	13	0.92 (0.53 to 1.58)
C82	Non-Hodgkin's lymphoma	104	**1.35 (1.11 to 1.64)**	128	1.13 (0.95 to 1.35)
C90	Myeloma	29	1.18 (0.82 to 1.70)	42	1.24 (0.92 to 1.69)
C91	Leukaemia	64	**1.35 (1.05 to 1.73)**	71	1.07 (0.84 to 1.35)

Statistically significant (α=0.05) increased risks are in bold, while statistically significant decreased risks are in italics.
*Adjusted for age at start of follow-up, birth year and sex.
ICD-10, International Classification of Diseases 10th Revision; ODSS, Occupational Disease Surveillance System.

associations for pancreatic and testicular cancer, myeloma, and NHL (LCL >0.9). Both groups had statistically significant reduced risk of lung cancer and the police had reduced risk of laryngeal cancer.

When the risk of each cancer site among firefighters was compared with the police, firefighters had statistically significant increased risk of mesothelioma and testicular cancer (table 3). Firefighters also had non-statistically significant increased risk of lung and kidney cancer and NHL (LCL >0.9). The police had a non-statistically significant increased risk of bone cancer compared with firefighters (LCL >0.9) (table 3). There were 273 workers who had worked in both firefighting and policing; exclusion of these workers did not significantly change the findings. When restricting to men, findings also remained unchanged.

DISCUSSION

This study aimed to identify cancer incidence among Ontario firefighters and police. Both occupations demonstrated an overall increased risk of cancer from any site, melanoma, and colon and prostate cancer compared with all other workers in the ODSS. They also had additional increased risk of cancers that differed among them. However, when comparing firefighters with the police and vice versa, many of the associations attenuated. We present a discussion of our results compared with other research findings.

Cancer risk among firefighters

Firefighters in our study experienced statistically significant elevated risk of many cancers, including a priori cancer sites identified by the IARC, which include prostate and testicular cancer and NHL.

We observed a higher risk of prostate cancer among firefighters than reported by the IARC, similar to existing literature.[1 7 8 10 11] Although it is unclear what exposures are linked to prostate cancer in firefighters, few factors have been postulated. Night and rotating shiftwork are common in protective services occupations and have been suspected to be involved in cancer development through disruption of the circadian rhythm.[1] Shiftwork has been classified by the IARC as probably carcinogenic to humans, based on limited evidence in humans.[1] The night shiftwork hypothesis was initially suggested for breast cancer and was extended to prostate cancer.[12] Firefighters are exposed to toxins through fire and smoke, which also include suspected prostate carcinogens such as arsenic and cadmium compounds.[13] It is also possible that firefighters have increased screening recommendations due to the nature of their job[14]; however, it is unclear what

Table 3 HR and corresponding 95% CI for firefighters compared with police, and police compared with firefighters, excluding all other workers in the ODSS cohort, 1983–2020

		Firefighters (n=13 642)		Police (n=22 595)	
ICD-10 code	Cancer site	Cases (n)	HR* (95% CI)	Cases (n)	HR* (95% CI)
C0–C97	Any cancer	1730	1.03 (0.96 to 1.09)	2377	0.97 (0.91 to 1.04)
C00	Lip	11	1.35 (0.57 to 3.22)	11	0.66 (0.28 to 1.53)
C01–C14	Oral	56	1.03 (0.72 to 1.46)	79	1.05 (0.74 to 1.48)
C15	Oesophagus	29	0.93 (0.57 to 1.50)	43	1.17 (0.72 to 1.88)
C16	Stomach	34	0.79 (0.51 to 1.21)	57	1.33 (0.87 to 2.06)
C18	Colon	152	0.97 (0.78 to 1.20)	203	1.06 (0.86 to 1.32)
C20	Rectum	66	1.19 (0.85 to 1.68)	76	0.81 (0.58 to 1.14)
C22	Liver	25	0.92 (0.54 to 1.56)	36	1.17 (0.69 to 1.99)
C25	Pancreas	53	1.09 (0.75 to 1.59)	63	0.88 (0.61 to 1.28)
C30	Nasal	<6		<6	
C32	Larynx	15	1.09 (0.54 to 2.18)	18	0.94 (0.47 to 1.88)
C34	Lung	210	1.11 (0.92 to 1.35)	237	0.89 (0.74 to 1.08)
C45	Mesothelioma	11	**3.21 (1.01 to 10.20)**	<6	
C40	Bone	<6		15	4.38 (0.99 to 19.5)
C43	Melanoma	125	1.01 (0.80 to 1.28)	184	0.98 (0.78 to 1.24)
C50	Breast (female)	7	0.78 (0.36 to 1.71)	80	1.27 (0.59 to 2.75)
C50	Breast (male)	<6		8	1.58 (0.47 to 5.28)
C53	Cervix	<6		12	0.58 (0.13 to 2.62)
C56	Ovary	<6		9	0.49 (0.11 to 2.27)
C61	Prostate	492	0.99 (0.88 to 1.12)	623	1.03 (0.91 to 1.16)
C62	Testis	30	**1.96 (1.19 to 3.23)**	29	*0.58 (0.35 to 0.95)*
C64	Kidney	94	1.31 (0.98 to 1.75)	97	0.75 (0.56 to 1.00)
C67	Bladder	120	0.94 (0.74 to 1.19)	169	1.13 (0.89 to 1.43)
C69	Eye	<6		8	2.08 (0.55 to 7.90)
C71	Brain	37	1.05 (0.68 to 1.62)	53	0.91 (0.59 to 1.38)
C73	Thyroid	27	0.75 (0.47 to 1.20)	72	1.16 (0.74 to 1.81)
C81	Hodgkin's lymphoma	10	1.33 (0.57 to 3.12)	13	0.68 (0.29 to 1.60)
C82	Non-Hodgkin's lymphoma	104	1.21 (0.92 to 1.58)	128	0.85 (0.65 to 1.11)
C90	Myeloma	29	0.94 (0.57 to 1.53)	42	1.01 (0.62 to 1.65)
C91	Leukaemia	64	1.15 (0.81 to 1.62)	71	0.80 (0.57 to 1.12)

Statistically significant (α=0.05) increased risks are in bold, while statistically significant decreased risks are in italics.
*Adjusted for age at start of follow-up, birth year and sex.
ICD-10, International Classification of Diseases 10th Revision; ODSS, Occupational Disease Surveillance System.

their actual screening behaviours are like compared with other workers. A more detailed description of prostate cancer in the overall ODSS cohort, including firefighters, has been previously published.[15]

We also observed a higher risk of testicular cancer (156%) among firefighters compared with all other workers and roughly twice the risk compared with the police. There is limited evidence supporting firefighting as an occupational exposure for risk of testicular cancer.[1 4] Although the literature is sparse on occupational causes of testicular cancer, few complex chemical compounds that may be present in fire smoke have been linked to testicular cancer, with limited evidence.[4 13 16]

For NHL, we observed a higher risk than reported by the IARC when comparing firefighters with all other workers in our cohort and a non-statistically significant elevated risk when compared with only the police. A recent meta-analysis observed an elevated risk (not statistically significant) of incidence of NHL and a statistically significant elevated risk of mortality from NHL.[4] Firefighters are exposed to benzene through fire[1 4]; however, the risk of NHL related to benzene exposure is less clear.[17 18] They may also be exposed to polychlorinated biphenyl (PCB) through fire smoke, which has been linked to NHL, with limited evidence.[13]

We observed an increased risk of leukaemia, specifically CLL, among firefighters compared with all other workers. A recent meta-analysis did not see an association for leukaemia[4] and previous studies reported varying findings.[19 20] Tsai *et al*[19] observed a statistically significant elevated risk of leukaemia overall and for AML, with a non-significant elevated risk of CLL.[19] Demers *et al*[20] observed a higher elevated risk of leukaemia in workers with 30 years of employment.[20] Although the IARC has reported sufficient evidence for benzene exposure causing AML, there is also some evidence linking benzene exposure to CLL[13] and firefighters can be exposed to benzene through fire and DEE.

Our finding for bladder cancer among firefighters is similar to the 12% increased risk reported in a recent meta-analysis,[4] although non-significant in our study. PAH and heavy metals (arsenic) are known bladder carcinogens,[13] with limited evidence for other exposures of DEE and soot.[13] Exposure to these agents could be through exposure to fire and smoke. Firefighters can also be exposed to DEE when working on or near fire trucks

that are frequently running, whether at the fire halls or when responding to emergencies.

Our increased risk of kidney cancer is within the incidence range reported by other studies (OR/SIR 1.27–1.59)[19 21 22]; this relationship has been shown to increase with duration in firefighting.[23] Arsenic and cadmium compounds and perfluorooctanoic acid (PFOA) are potential exposures through fire smoke and have been linked to kidney cancer, with limited evidence.[13] When compared with the police the relationship remained elevated, but no longer significant. This may be due to exposures to fire smoke that are not similar for the police.

We observed elevated mesothelioma among firefighters, which became significant when restricting our comparison group to the police. Many workers in the ODSS may be exposed to asbestos (eg, construction workers, maintenance staff), whereas the police may be less likely to be exposed to asbestos, which explains the strengthening relationship when compared with the police. Our finding was similar to other studies (SIR=2.29–2.59), although these findings are based on firefighters compared with the general population.[5 21 24] Firefighters are exposed to asbestos fibres from burning older buildings[24] and may be more exposed during the overhaul stage when they are involved in tasks related to ripping up walls, floors and ceilings.

A more than twofold statistically significant excess risk of melanoma was observed among firefighters. Our finding was higher than another study of Canadian firefighters where an HR of 1.58 (95% CI 1.11 to 2.25) was reported.[7] Many studies have reported an increase in melanoma.[19 24 25] A previous study found the risk of melanoma largely reduced when comparing firefighters and police, similar to our study.[26] Firefighters may be exposed to solar radiation while working outside during calls, training or performing errands. They also have the potential to be exposed to PCB through inhalation or dermal absorption when exposed to fire and smoke.[13 27]

It is speculated that dermal exposure to soot resulting in exposure to other agents (eg, PCB, PAH) and smoke particulates may contribute to an elevated risk of melanoma.[4 19] Light-coloured skin is a known genetic risk factor for melanoma.[28] Although we do not have data on ethnicity or skin type in our cohort and there is a lack of reporting on ethnicity in Canadian firefighters, it is possible that firefighters have a higher proportion of Caucasians than other occupations. The relationship was attenuated when compared with the police and this may be because the police also spend time outdoors or because of ethnic similarities between the two groups.

We observed a statistically significant increased risk of colon cancer among firefighters, which supports the findings from a previous meta-analysis,[4] although we only observed a non-statistically significant increased risk of rectal cancer. Findings may be related to shiftwork, ionising radiation and asbestos exposure based on limited evidence.[12 13 29 30]

We reported a higher pancreatic cancer rate than a Nordic study (SIR=1.17, 95% CI 0.94 to 1.45)[24] and a recent meta-analysis on mortality (SMR=1.13, 95% CI 0.99 to 1.29).[4] Another Canadian study did not report an association[7]; however, the association weakens when compared with the police.

Cancer risk among the police

The police had similar findings to firefighters for prostate and colon cancer and melanoma, among other associations. Findings in our study show increased cancer risk among the police, although results vary in the existing literature.

Evidence on the risk of prostate cancer among the police has been inconsistent,[31–34] but a recent Canadian study reported a 28% excess risk.[7] Similar to firefighters, findings may be linked to night and rotating shiftwork and increased screening behaviours, although it is unclear if police officers seek out prostate cancer screening more than other workers. Further details on prostate cancer among the police and the overall ODSS cohort have been previously published.[15]

A non-statistically significant increase in testicular cancer disappeared and became statistically protective when compared with firefighters. Previous studies showed mixed results.[35 36] No clear relationship has been established regarding radar exposure during policing, which may explain this.[37 38] Two studies examined if use of hand-held traffic radar units near the testicles would be a possible factor in the risk of testicular cancer.[37 38]

The increase in bladder cancer incidence among the police is similar (OR=1.40, 95% CI 1.00 to 1.90) to results found in Switzerland[36] and is supported by a US study reporting a four-fold increase in mortality with 40 years or more of police experience.[32] However, Wirth *et al*[6] reported a decreased incidence (SIR=0.64, 95% CI 0.39 o 0.99)[6] and several mortality studies did not observe associations.[34 39] It is unclear what exposures may be related to risk of bladder cancer among the police, but they may be exposed to diesel exhaust if working on roadways or near idling vehicles.

A non-statistically significant excess risk of NHL was observed among the police when compared with all other workers, and previous studies have primarily reported no association.[6 31 36] However, Forastiere *et al*[34] did report an increased risk specifically in motorcycle police (OR 5.14).[34] We observed a non-statistically significant elevated risk of myeloma among the police, similar to previous Canadian findings[7]; however, this was no longer observed when compared with firefighters. In a previous literature, the risk of myeloma among the police was not explicitly discussed and at times grouped into a broader cancer group of lymphomas. No association was observed for the different subtypes of leukaemia.

A more than twofold statistically significant excess risk of melanoma was observed among the police compared with all other workers. Our study finding was higher than two previous Ontario studies that reported increased risk of melanoma (HR=1.28, 95% CI 1.32 to 2.16; SIR=1.45, 95% CI 1.10 to 1.90).[7 35] Mortality from melanoma was also found to be higher in a previous study.[36] Findings may be related to solar radiation specifically for the police that work outdoors (eg, traffic police) or related to unknown carcinogen exposure. When compared with firefighters, the relationship attenuates and this may be a result of similar outdoor exposures or ethnic similarities between the two groups. Based on the Canadian census data from 2016, few Canadian police (~8.4%) identify as visible minorities[40] and this may bias our findings.

Although most research has not observed increase in thyroid cancer among the police,[32 34–36 39] one study did report an increased risk (relative risk (RR)=2.21, 95% CI 1.23 to 3.66),[41] higher than our study. Few known or suspected causes of thyroid cancer exist; however, exposure to X and gamma radiation for specialised tasks may exist among the police (eg, use of security/forensic devices).

We observed a statistically significant increased risk of colon cancer among the police and no association for rectal cancer. Bouchardy *et al*[36] observed a non-statistically significant elevated incidence of colon cancer among the police (OR=1.10, 95% CI 0.90 to 1.50),[36] and another study did not observe any association (SIR=0.80, 95% CI 0.53 to 1.14).[31] Findings for colon

and rectum cancer could be related to shiftwork, among other possible exposures such as ionising radiation or asbestos.[13]

Our findings on female breast cancer add to the sparse literature on female police. One study reported no association for cancer mortality among female police[32]; however, other mortality and incidence studies reported an increase in male breast cancer among the police.[7 34] Risk of breast cancer may be due to shiftwork exposure.[13]

Decreased risk among firefighters and police

We observed a statistically significant decreased risk of lung and laryngeal cancer among firefighters and police; these findings attenuated when comparing firefighters with the police and vice versa. Generally, research has shown no association of lung cancer among firefighters[4] and police.[6] However, in a large US cohort of firefighters an increase in lung cancer was observed,[19] and in a Nordic cohort of firefighters an increase in lung adenocarcinoma was observed.[24] It is possible that firefighters and police smoke less than other workers in the cohort. Firefighters in the USA have been shown to have lower smoking rates (<20%) than military personnel and other adult men.[42] We could not account for tobacco smoking in our study, but it is unlikely that this has impacted our findings as we would have expected to see an elevated risk of lung and laryngeal cancers, which are associated with smoking.

Limitations and strengths

There are several limitations to this study. Occupation is only based on job title entered at the time of the worker's compensation claim, which can lead to non-differential misclassification of the exposure group, biasing estimates towards the null. With job information at a single point in time, we cannot assess changes in jobs or duration of employment. Further, there are no exposure measurements or exposure surrogates used in this analysis, which limits our ability to evaluate exposure levels to specific cancer sites. Most WSIB claims are compensated for musculoskeletal-related injuries, which may introduce bias if exposures differ between compensated and non-compensated workers.

Lack of information on personal characteristics (eg, smoking habits, ethnicity, screening behaviours) limits our ability to control for possible confounders. Firefighters and police may have reduced smoking and alcohol consumption habits than other workers due to the physically demanding nature of their work and assessments prior to working as firefighters or police.[43] A recent report on trends in cigarette smoking and smokeless tobacco among firefighters and law enforcement personnel showed a declining trend in cigarette smoking, but observed use of smokeless tobacco to be higher than in other workers.[44] Body mass index has been thought to be a poor measure of obesity in individuals with high muscle mass and may not be appropriate for this study. Race and ethnicity may play a role in findings specific to melanoma as many firefighters and police are likely to be Caucasian.

Firefighters and police may have better access to screening recommendations compared with other workers. In Canada, firefighters are provided with health recommendations regarding cancer screening, but it is up to each worker to request screening from the primary physician. The healthy worker effect could still influence findings in this study as firefighters and police have stringent physical fitness requirements on entry into the profession and may be healthier than other occupations in the ODSS cohort, leading to healthy worker effect.

Comparison of firefighters with the police and vice versa may help to reduce potential confounding by these factors and the healthy worker effect. Our study makes multiple comparisons, which can lead to chance findings; however, many of our study findings are supported by previous literature and the interpretation is based on existing evidence.

This study also has several important strengths. Through linking administrative health data, this cohort provides a large sample of workers to identify many cancer sites, even relatively rare, based on cancer registry information, rather than mortality, which previous studies have focused on. The side-by-side analysis of firefighters and police, two groups that have similar entry requirements related to physical fitness and tend to have a similar socioeconomic status, provides a lens through which we can consider the unique occupational exposures of each group. Contribution to the body of literature on cancer incidence among the police, with the inclusion of female police, is also a strength of this study as there are limited studies on cancer among the police. The evidence from this study can provide insight on WSIB policies regarding prescribed cancers in Ontario for firefighters and be useful for workers, employers and policy makers. The ODSS cohort will be updated on an ongoing basis, providing up-to-date administrative health data, including cancer diagnoses. Our findings are comparable with previous studies and provide evidence for shared cancer risk among firefighters and police.

Our study had the ability to follow a substantial number of workers to examine cancer incidence. Our findings align with a priori cancer sites of interest among firefighters and for colon cancer risk among the police, among other cancers identified. Based on our findings, further investigation on exposures involved in these occupations is needed. Many of our findings attenuated when comparing firefighters with the police and vice versa, which may imply that there are common exposures involved, compared with other workers in the cohort. For example, shiftwork should be further investigated given the elevated risk of breast, prostate and colon cancer in these occupations. This can lead to the protection of workers and improvement of prevention strategies.

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Contributors PAD conceived of the work, provided overall support for the design of this work, and is the guarantor of the overall content. JS conducted data preparation, created the analysis plan and drafted the manuscript and tables. MD and AL assisted with the analyses. JS, TLK, JM, NM, AL, MD, CL-H, TN, NLD and PAD participated in the interpretation of the data, provided critical review of the work and the manuscript, and provided expertise in occupational health.

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