

The Risk of Prostate Cancer from Occupational Exposures in Male Firefighters

Zing-Wae WONG* ¹, James GOMES ²

¹ Student, University of Ottawa, Canada

² Professor, University of Ottawa, Canada

* *Auteur(e) correspondant* | *Corresponding author*: N/A

Résumé :

(traduction)

Le cancer de la prostate est le cancer le plus fréquemment diagnostiqué chez les hommes. Étant donné qu'il se développe lentement, on peut prévenir la mortalité si on détecte et traite la tumeur alors qu'elle n'en est encore qu'à ses premiers stades de développement. On a démontré que des facteurs environnementaux pouvaient augmenter le risque de cancer de la prostate. Quelques recherches ont été effectuées sur les niveaux de cancer de la prostate chez les pompiers, mais peu d'articles ont été publiés à ce sujet. Cette étude vise à trouver une corrélation entre le métier de pompier et le niveau de cancer de la prostate. L'article indique des agents cancérigènes potentiels liés au métier de pompier. Cette étude analyse cinq articles ayant utilisé différentes méthodes d'obtention des cas et des cohortes étudiés, ainsi que diverses méthodes de comparaison. Néanmoins, les articles étudiés ont conclu à une corrélation positive entre le niveau d'exposition des pompiers dans le cadre de leur métier et le niveau de cancer de la prostate. Les produits chimiques suspectés d'être des agents cancérigènes par ces études sont les hydrocarbures aromatiques polycycliques (HAP) et la fumée d'incendie. Cependant, les études ultérieures devront être plus rigoureuses dans le calcul des niveaux de cancer de la prostate, en tenant compte de facteurs liés au style de vie, et d'autres variables confondantes comme le tabac et la durée estimée de l'exposition.

Mots-clés :

Pompier, exposition professionnelle, néoplasme de la prostate

Abstract:

Prostate cancer is the most commonly diagnosed cancer among men. Since prostate cancer is a slow developing cancer, mortality can be prevented if the tumour is detected and treated in its early stages. There is proof that environmental exposures can increase the risk of prostate cancer. Many papers have performed data analyses on prostate cancer levels in firefighters. There has been some research on firefighter prostate cancer levels but few reviews on the topic. This paper focuses on finding whether there is a correlation between firefighting occupation and levels of prostate cancer. As well, this paper notes potential carcinogens within the firefighting occupation. Five papers were included in this review; these papers used different methods to obtain the cases and cohorts for the study. The papers also used different controls for comparison. Nevertheless, the papers found in the search supported a positive correlation between exposures in firefighting occupations and the level of prostate cancer. The two chemicals that were suspected carcinogens in these studies were Polyaromatic hydrocarbons (PAH) and fire smoke. However, future research can be more rigorous in calculations of prostate cancer levels by including lifestyle factors, other confounders such as smoking, and estimated length of exposure.

Keywords:

Firefighting, occupational exposure, prostate neoplasm

Introduction

Prostate cancer is the most commonly diagnosed cancer among men and the second most common cause of cancer mortality among men (Haas & Sakr, 1997). Each year, 25,500 Canadian men are diagnosed with prostate cancer (Prostate Cancer Canada, 2009). Both biological and environmental factors have been correlated with prostate cancer. Studies have shown that the main risks for prostate cancer cannot be altered: age, race and genetics. Many prostate cancer diagnoses occur in men over 60 years of age. More African-American males than Caucasian Americans are diagnosed with and die of prostate cancer. In addition, first degree family members with prostate cancer is a positive indication of the risk of developing prostate cancer. The risk is higher if the father's side of the family has a history of prostate cancer than if the mother's side has a family history of prostate cancer (Flinton & Walters, 2005; Hsing & Chokkanlingam, 2006; Cancel-Tassin & Cussenot, 2005). Although the main risks are biological, and thus cannot be changed, the pathogenesis of prostate cancer is also linked to environmental exposures which can be altered.

Ninety percent of prostate cancer can be cured if it is treated early (Prostate Cancer Canada, 2009). Identifying the chemicals that increase the risk of prostate cancer; exposures to these chemicals typically occur at workplace and are, therefore, occupational in nature. Firefighters are exposed to a number of chemicals in their work environment which is dynamic and the chemicals range from innocuous to known carcinogens (Kang, Davis, Hung, & Kriebel, 2008). During an "overhaul" procedure where firefighters extinguish hidden fires, self-contained breathing apparatus are not used. During the "overhaul" procedure which can last hours, and during actual firefighting the nature of exposure depends on the type of fire and the material that is burnt (Bolstad-Johnson, Burgess, Crutchfield, Storment, Gerkin, & Winston, 2000). Some of these exposures among firefighters include exposures to vapours and fumes of metals and organic chemicals, some of which are carcinogens. Typical exposures among firefighters are exposures to lead, antimony, cadmium, uranium, benzene, methylene chloride, polyaromatic hydrocarbons (PAH), perchlorethylene, toluene, and noncrystalline silica (Brandt-Rauf, Fallon, Tarantini, & Andrews, 1988; Fabian et al., 2001; Jankovic, Jones, Burkhar, & Noonan, 1991; Austin, Wang, Ecobichon, & Dussault, 2001).

Firefighters are at risk of developing a range of cancers

among other health problems and these include leukemia, bladder cancer, brain cancer, colon cancer, kidney cancer and non-Hodgkin's lymphoma (Kang et al., 2008; Golden, Markowitz, & Landrigan, 1995; Guidotti, 1995; Guidotti, 2007; Youakim, 2006). A preliminary search of the scientific literature on prostate cancer and occupation indicated that prostate cancer among firefighters was under-reported. Prostate cancer is the most commonly diagnosed cancer in men and occupational exposures have been reported to be associated with cancer development (Pukkala et al., 2009). Considering the extent of carcinogenic exposure and the prevalence of prostate cancer among firefighters, there may be a likely correlation between firefighting as an occupation and prostate cancer. The prevalence of prostate cancer among other cancers among firefighters has been reported to be higher (LeMasters et al., 2006; Bates, 2007). This study focuses on the development of prostate cancer among firefighters and its association with occupational exposures in firefighting. We also hope to identify potential chemicals and other burning substances that may be associated with the development of prostate cancer.

Methodology

A literature search was conducted to find relevant articles that reported of the risk of prostate cancer among firefighters. The search strategy was developed in Medline with the help of the reference librarian and once developed it was used to search all the relevant scientific databases. The search terms used were: "firefighters, prostate neoplasm, risk, occupational and environmental exposures." MeSH terms were used when possible otherwise text words in title and abstracts were searched. The search was conducted on the following databases: Ovid, Toxline, PubMed, Scopus and CINAHL. The time frame for the search was since inception to May 2010 and only articles on humans were included.

The inclusion criteria were case studies, cohort studies or cross-sectional studies reporting on the incidence and prevalence of prostate cancer among firefighters and its association with occupational exposures. The exclusion criteria were articles in languages other than English, animal experimentation studies and studies not reporting occupation as a risk factor for prostate cancer. The search results produced 185 articles in Ovid, of which fourteen articles fit the inclusion criteria. Toxline yielded no results.

PubMed showed two results, of which one was new. Scopus yielded 6 results, of which two were relevant. CINAHL yielded 1 review article. The review article on firefighters and the other original research articles are the basis of this paper.

All the searched articles were initially reviewed by reading the title and abstract and the ones that meet the inclusion criteria were retained for further scrutiny. At this stage the full article was reviewed and the relevant ones were included in this review. The selected articles were reviewed and relevant data on population demography, exposures, risk estimates, major findings and overall inferences was extracted using the PICO strategy (Hassig, 2009).

Results

From the many articles searched, fourteen articles met the search criteria and 5 were included: 3 case studies, 2 cohort studies, and no cross-sectional studies. The studies feature firefighters who were diagnosed or died of prostate cancer. These studies included between 981 and 60,878 cases of prostate cancer. Statistical tests were employed, by the studies, to find the correlation between exposures during firefighting and levels of prostate cancer.

Bates (2007) analysed records of all male cancers registered in California between the years of 1988-2003 and found 3,659 had firefighting (not administrative work in fire department) in the "occupation and industry" text fields. The data also shows that 1,144 of these firefighters had prostate cancer. A logistic regression was done in this case study using other cancers as a control to generate an odds ratio. The logistic regression models were controlled for age (5 categories), year of diagnosis (4-year categories), ethnicity, and socioeconomic status (5 categories). The results show a statistically significant positive odds ratio (OR) between firefighting and prostate cancer (OR = 1.22; 95% CI: 1.12-1.33) (Bates, 2007).

Krstev, Burgess, Crutchfield, Storment, Gerkin, and Winston (1998a,b) performed two case studies on prostate cancer: a smaller study based on 981 pathologically confirmed prostate cancer cases (Krstev et al., 1998a) and a larger study based on 60,878 American men who died of prostate cancer (Krstev et al., 1998b). The smaller case study by Krstev et al. (1998a) which was a case study on 981 new pathologically confirmed prostate cancer cases included 479 blacks and 502 whites who were diagnosed between 1986 and 1989, and 1,315 population controls (594 blacks

and 721 whites). All of the cases and controls resided in either: Atlanta, Detroit, or in 10 counties in New Jersey. Data on cancer history was obtained through cancer registries. Information on occupation, including lifetime work history, was collected by in-person interview. In this small case-control study, the authors calculated odds ratios (ORs) with 95% confidence intervals (95% CI). The results indicated that firefighters had an increased risk of developing prostate cancer (chi2 trend, $p = 0.02$) (Krstev et al., 1998a). Due to the dependence on recall, the interviews can only show patterns of chemical exposure without scientific validity. Thus no chemical exposure can be conclusively linked to increasing risk of prostate cancer. Under the Standard Occupational Classification (SOC) by the U.S. Department of Commerce in 1980, Firefighters with and SOC of 512 had an OR = 3.85; 95% CI : 1.34-11.1. Firefighters with an SOC of 5123 had an OR = 3.34; 95% CI : 1.13-9.91 (Krstev et al., 1998a).

In a study of death certificates in 24 states, Krstev *et al.* (1998b) performed another case study that included 60,878 U.S. men with prostate cancer as underlying cause of death. The subjects were matched with controls that had died of all other causes except cancer, from 1984 to 1993. The industrial and occupational information were obtained from death certificates. Risk of prostate cancer mortality were shown to increase with increasing years of employment in firefighting (chi2 trend, $p=0.02$). Krstev *et al.* (1998b) notes the prevalence of the chemical PAH in firefighting. There were 140 cases of prostate cancer among whites, yielding a mortality odds ratio (MOR) of 1.2, 95% CI : 1-1.4 (Krstev et al., 1998b). There were 13 cases of prostate cancer among African Americans yielding a MOR = 2.2; 95% CI : 1.2-3.9 (Krstev et al., 1998b). The authors noted a significantly increased MOR of prostate cancer.

Ma *et al.* (1998) performed a cohort study using data from the National Cancer Institute, the National Institute for Occupational Safety and Health, and the National Center for Health Statistics. These institutions collected data on cause of death and occupation since 1984 on 24 states (Colorado, Georgia, Idaho, Indiana, Kansas, Kentucky, Maine, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Rhode Island, South Carolina, Tennessee, Utah, Vermont, Washington, West Virginia, and Wisconsin). The data was coded by the Bureau of Census Index of Industries and Occupations using death certificates. Among the firefighters, there were 1883 cancer deaths of which 1817 occurred in whites and 66 in blacks. The MOR was calculated for black

and white firefighters in which all deaths except cancers were used as the reference for the occupation. Then the MOR was adjusted for year and age of event. The only cancer that was elevated in both black and whites was prostate cancer (whites: MOR = 1.2; 95% CI : 1.0- 1.3; blacks: MOR = 1.9; 95% CI : 1.2-3.2) (Ma et al., 1998). However, the authors noted that this study lacks information on lifestyle, specific exposures, and other confounders related to disease outcome; therefore, more research is needed.

Demers, Checkoway, Vaughan, Weiss, Heyer, and Rosenstock (1994) performed a cohort study to determine if fire smoke increased the risk of prostate cancer. A cohort of 2,447 male firefighters in Seattle and Tacoma was used for the study. The population was followed for 16 years (1974-89). Incidence of cancer was ascertained using a population-based tumour registry; the control was the local rates among 1,878 policemen from Seattle and Tacoma. The 66 incidences of prostate cancer among firefighters was slightly elevated compared to the policemen (standard incidence ratio [SIR] = 1.4; 95% CI : 1.1-1.7) (Demers et al., 1994). Nevertheless, the sample was small; the correlation was not strong and was not related to the number of years of exposure.

Discussion

This review supports the hypothesis that prostate cancer is correlated with the firefighting occupation, however, the exact chemicals which are involved are not known, but a number of putative occupational exposures are reported. In this review the required information on incidence and mortality of prostate cancer among firefighters in the selected studies were obtained from death certificates, tumour registries and other confirmed cases. In these studies controls were selected from the population, other cancers, or other occupations. The studies could have included exposure matrices in their calculations to account for cumulative exposure. These results only show an overall correlation without information on the relationship between the length of work as a firefighter and the degree of risk of prostate cancer. A review by LeMasters *et al.* (2006) supported the positive correlation between firefighting occupations and prostate cancer and reported a summary estimate risk of SRE = 1.28; 95% CI: 1.15-1.43 following a systematic review and meta-analyses of thirty two studies on cancer risk among firefighters. It is believed that firefighters by virtue of their occupation are susceptible to a number of cancers including multiple myeloma, non-Hodgkin's

lymphoma and testicular cancer (LeMasters et al., 2006). PAH (Krstev et al., 1998b) and fire smoke (Demers et al., 1994) are suspected carcinogens but the relationship has not been confirmed although believed to be plausible. The main reason for the inability to confirm the carcinogens is because the chemical identification is based on estimates of chemical exposures within different occupations. Nevertheless, fire smoke and PAH are correlated with increased rates of prostate cancer among firefighters but the relationship is not proven to be causal. Moreover, it is also believed that firefighters at work are exposed to fumes, vapours and contaminated air in places where fire is burning. These fumes and vapours that emerge from burning materials are harmful substances comprising benzene, n-hexane, vinyl chloride, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, N-nitroso compounds, lead, arsenic and mercury among others (Bates, 2007). Firefighters are exposed to mixtures of chemical substances some of which are carcinogenic. The routes of exposure and delivery to target organs include skin, respiratory system and ingestion. These exposures at the site of contact or target organs produce direct and indirect effects associated with modulation of biochemical or physiologic pathways and other pathways of toxicity (LeMasters et al., 2006). Although firefighters use standard protective equipment which include thermal gear, respirators and face shields the exposures transcend these barriers and impose undue body burden on the firefighters (Coca, Williams, Roberge, & Powell, 2010). Heavy physical activity during firefighting enhances the exposure of the firefighter in spite of all the protective equipment.

Firefighters are susceptible, because of occupational exposures, to a number of cancers and prostate cancer is one of the major cancers. A number of exposures occur during the firefighting "overhaul" procedures. Firefighters are exposed to carcinogenic toxicants which increase the risk of cancers. Although this review shows that there is a positive correlation between prostate cancer and firefighting, individual substances have not been identified, more rigorous research is, therefore, needed. In particular, more information is needed on potential carcinogens present in the workplace of firefighters. It is also necessary to evaluate exposures more efficiently by quantifying exposure into exposure matrices and identifying the nature and the intensity of exposures through dosimetry. The duration of exposure for an individual during ones tenure as a firefighter and the latency period also needs to be considered. Appropriately designed protective equipment would cer-

tainly help in protecting the firefighters on their job. Confounders such as lifestyle factors should also be accounted for in the calculations of future research.

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Appendix: Data Collected

Study Title and Reference	Population	Exposures	Prostate Cancer Risk	Major Findings
Krstev, S., 1998a	981 new cancer cases (479 blacks and 502 whites) diagnosed between 1986 and 1989, and 1,315 population controls (594 blacks and 721 whites); in Atlanta, Detroit, and 10 counties in New Jersey.	No occupational exposures were identified as potential risk factors	Firefighters with an SOC of 512 had an OR = 3.85; 95% CI : 1.34-11.1. Firefighters with an SOC of 5123 had an OR = 3.34; 95% CI : 1.13-9.91. *SOC= Standard Occupational Classification (SOC)	Occupation was not a major determinant of prostate cancer risk.
Krstev, S., 1998b	60,878 U.S. men with prostate cancer as underlying cause of death was selected and matched with controls who died of all other causes except cancer, from 1984 to 1993.	PAH-possible carcinogen	(MOR) of 1.2, 95% CI 1-1.4. There were 13 cases of prostate cancer among African Americans yielding a MOR = 2.2; 95% CI : 1.2-3.9.	An excess of prostate cancer risk was observed in low social economic status occupations
Bates, M. N., 2007	Searched male cancers registered in California (1988-2003); 3,659 firefighters, 1,144 had prostate cancer		OR = 1.22; 95% CI: 1.12-1.33	Supports hypothesis that firefighting exposures may increase risk of cancer
Ma, F., 1998	1,883 male firefighters in 24 states who had died of cancer.		Prostate cancer risk was elevated in both groups (whites: MOR = 1.2; 95% CI = 1.0-1.3; blacks: MOR = 1.9; 95% CI = 1.2-3.2).	The overall cancer mortality was slightly elevated among white firefighters but the increase was not significant among black firefighters. Only prostate cancer was elevated in both groups. More research is needed to confirm the existence of differential rates of cancer mortality risks among firefighters of different race/ethnic subpopulations.
Demers, P. A., 1994	2,447 male firefighters in Seattle and Tacoma, (Washington, USA). The study population was followed for 16 years (1974-89).		(SIR = 1.4, 95 percent confidence interval [CI] = 1.1-1.7) (incidence density ratio [IDR] = 1.1, CI = 0.7-1.8)	The correlation was not strong but an increased risk was found.