

**THE OCCUPATION OF FIREFIGHTING AND CANCER RISK:
ASSESSMENT OF THE LITERATURE**

Report to
The Workers Compensation Board of British Columbia

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EXECUTIVE SUMMARY

Cancer Care Ontario was commissioned by the Policy and Regulation Development Bureau of the Workers' Compensation Board of British Columbia to undertake a project considering the association between the occupation of firefighting and certain cancers. Specifically, the goal of this project was to synthesize and analyse the literature regarding the causal association between the occupation of firefighting and cancers of the brain, kidney, bladder, ureter, colon, testes, non-Hodgkin lymphoma, leukemia, lung cancer in non-smokers, and multiple myeloma.

A systematic literature search was conducted for studies published in English between 1966 and the end of 2003. All analytic studies which provided risk estimates in comparison to a non-firefighter population were eligible for inclusion. Each eligible study underwent quality assessment by two independent reviewers. This resulted in 18 studies being included and 15 studies being eliminated from further analysis. Data were extracted by cancer site and were pooled across studies using a random effects model, a standard meta-analytic technique. Incidence and mortality were analysed separately.

Our review found limited evidence of increased risks for brain cancer and colorectal cancers associated with the occupation of firefighting. We found no evidence of an increased risk for lung cancer or kidney cancer. For the remaining cancers considered, there were insufficient data to determine whether or not there is an increased risk associated with the occupation of firefighting. Sensitivity analyses were conducted for cancers for which there were sufficient data. Conclusions for cancers did not change when analysis was restricted to studies having larger numbers of cases.

Limitations of the studies in this review include: small numbers of cases resulting in low statistical power and limited data for analysis of a dose-response relationship, limited or no data available on confounders, and inadequate measures of individual exposures or exposure indices. There is evidence to suggest that firefighters have reasonable potential for exposure to a number of substances which have been shown to be carcinogenic to humans or to animals. Studies have documented concentrations at some structural and wildland fires which are in excess of recommended short-term or ceiling exposure levels. Further research is recommended.

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1.0 Background

Firefighters have potential for exposure to a large number of substances, some of which have been classified as known or suspected carcinogens and some of which have not yet been evaluated for carcinogenicity. These substances include benzene, formaldehyde, polycyclic aromatic hydrocarbons, asbestos, and diesel exhaust, among others. Exposure to these agents can occur in various phases of fighting a fire, including knockdown or suppression (during which the fire is extinguished) and overhaul and salvage (after the fire is exhausted and clean-up and assessment begin).

Assessing relationship between occupational exposures and cancer risk is challenging for a number of reasons, including long latency periods associated with cancers, the difficulty in establishing a baseline risk, and difficulties associated with obtaining data on occupational exposures. Studies have suggested an underestimation of occupational cancers because occupational hazards are not the subject of systematic study (Siemiatycki , 1991).

Firefighter Characteristics

Few published studies have compared the characteristics of firefighters with that of the other workers or the general population. In terms of smoking habits, studies have reported that firefighters have smoking rates similar to or lower than that of police officers (Brackbill et al., 1988; Stellman et al, 1988; Sama et al., 1990), similar to other blue collar workers (Dibbs et al., 1982; Sama et al., 1990; Bates, 1987) or similar to the general population (Nelson et al., 1994).

A study of white male participants in the Normative Aging Study, a longitudinal study, reports baseline values for body mass index, blood pressure, and serum cholesterol which were similar for firefighters and non-firefighters (Dibbs et al., 1982). The study also reports that firefighters were not at increased risk for coronary heart disease over a 10 year period as compared to non-firefighters. A prospective cohort study of Cincinnati firefighters found that, when compared to employed males in the National Health and Nutrition Examination Survey (NHANES I), firefighters were on average heavier but had, on average, normal lipid and blood pressure profiles (Glueck et al., 1996).

Firefighter Exposures

Toxic substances to which firefighters may be exposed can take a number of forms (e.g. particulates, vapors, gases) and depending on the substance exposure can occur through inhalation, ingestion, or skin contact. Published studies have documented firefighter exposures at structural fires, training fires, and wildfires (Austin et al., 2001; Hung & Shih, 1997; Lees, 1995; Golden et al., 1995; Froines et al., 1994; Atlas et al., 1985). Table 1 provides a list of some of the agents to which firefighters may be exposed and the cancer sites for which these agents are known to be carcinogenic.

Studies have recorded concentrations of specific exposures, during both suppression and overhaul of structural fires and wildland fires, which are in excess of recommended ceiling or short-term exposure levels (Brandt-Rauf et al., 1988; Bolstad-Johnson et al., 2000; Austin et al.,

2001; Gold et al., 1978; Treitman et al., 1980; Jankovic et al., 1991; Materna et al., 1992; Reinhardt et al., 1994; Reinhardt & Ottmar, 2000). In a study of exposures during overhaul of 25 structural fires, Bolstad-Johnson and colleagues report concentrations in excess of NIOSH or ACGIH ceiling or short-term exposure levels for acrolein, benzene, carbon monoxide, formaldehyde, glutaraldehyde, nitrogen oxide and sulfur dioxide. In a study of 14 calls over a 10-day period, Brandt-Rauf and colleagues report excessive concentrations of benzene, carbon monoxide, sulfur dioxide, hydrogen cyanide, and aldehydes (formaldehyde, acrolein, and acetaldehyde). In a study of two Boston Fire Department units, Trietman and colleagues (1980) report excessive concentrations of carbon monoxide, hydrogen cyanide, hydrogen chloride, and particulates. Jankovic and colleagues (1991) report concentrations of formaldehyde, acrolein, hydrogen chloride, hydrogen cyanide, sulphuric acid, and hydrogen fluoride which exceeded short-term exposure limits at some fires. Measurements were made during both knockdown and overhaul phases of structural firefighting.

In a series of experimental fires, containing common building materials and household items, such as bed mattresses, insulation foam, gasoline and plywood, Austin and colleagues (2001b) report fourteen volatile organic compound products which were present in high concentrations: propene, benzene, xylenes, 1-butene/2-methylpropene, toluene, propane, 1,2-butadiene, 2-methylbutane, ethylbenzene, naphthalene, styrene, cyclopentene, 1-methylcyclopentene, isopropylbenzene. A number of these (benzene, styrene, and 1,3-butadiene) are classified by IARC as carcinogenic. In a study of calls received at the City of Montreal Fire Department over a twelve month period, Austin and colleagues (2001c) report that 41% of all fires were structural fires, 17% were vehicle fires, and 42% were miscellaneous fires (garbage, etc).

Asbestos, which was widely used as insulation until the early 1970's, can still be found in structures where it is normally well contained. As the encasing material is damaged, however, asbestos fibers may be released during combustion or during overhaul. A study of New York City firefighters on active duty during the 1960's documented pleural abnormalities (including typical asbestos-induced pleural thickening) in 20% of 212 firefighters studied (Markowitz et al., 1991). Both short and long term asbestos exposure have been associated with cancers of the lung, colon, rectum, and mesothelioma of the pleura and peritoneum (Homa et al., 1994; IARC, 1987).

Firefighters are also exposed to mixtures of polycyclic aromatic hydrocarbons (PAHs) (Brandt-Rauf et al., 1988; Bolstad-Johnson et al., 2000). Although studies have not tied specific PAHs to cancer in humans, combinations of PAHs (e.g. soot, coal tars, diesel exhaust) have been classified by IARC as carcinogenic to humans (IARC, 1987). In animal studies, specific PAHs have been found to induce tumours of the lung, skin, and bladder. (Boffetta et al., 1997; IARC, 1987). There may also be an association with brain cancer (Inskip et al., 1995).

Self-contained breathing apparatus (SCBA) were introduced for firefighters over the last two decades and are widely used. For a number of reasons firefighters may remove their masks for short or extended periods of time.

**Table 1: Firefighters' Toxic Exposures
IARC Classification, Sources of Exposure, and Cancer Sites**

Agent	IARC¹ Classification, Date Classified	Potential Sources of Exposure During Firefighting	Cancer Sites (from IARC Monographs)
Acetaldehyde	Group 2b, 1999	Engine exhaust, residential fires	Bronchus, oral cavity, pharyngeal, laryngeal, esophageal
Acrolein	Group 3, 1995	Burning wood, carpeting, upholstery, metals, plastics, engine exhaust, fossil fuel combustion	Insufficient human evidence
Acrylonitrile	Group 2b, 1999	Rubber and textiles	Lung, brain
Asbestos	Group 1, 1987	Burning insulation materials, crumbling and demolition of structures during overhaul phase	Lung, pleura, peritoneum, GI tract, colon, rectum, larynx
Benzene	Group 1, 1987	Present in almost all fires, material decomposition –mattresses, insulation	Leukemia
1,3 - Butadiene	Group 2a, 1999		lymphohaematopoietic cancers
Chloroform	Group 2b, 1999	Decomposition of organic matter, solvent constituent	Liver, kidney, bladder, rectum/large intestine
Crystalline silica	Group 1, 1997	Concrete dust, soil and sedimentary rock dust, wildland fires	Lung
Diesel engine exhaust	Group 2a, 1989	Trucks started inside firehouses	Lung, bladder
Formaldehyde	Group 1, 2004	Textiles, particle board, paints, carpets, wildland fires	Nasopharyngeal, leukemia, brain
Glycidaldehyde	Group 2b, 1999	A metabolite of acrolein	Insufficient human evidence
Soot	Group 1, 1987	Formed during incomplete combustion of materials	Lung, skin, esophageal
Styrene	Group 2b, 2002	Plastics and textiles	lymphohaematopoietic cancers
Vinyl chloride	Group 1, 1979	Component of plastics, metals, insulation, packing material	Brain (particularly gliomas), lung, liver (angiosarcoma), haemo- lymphatic system, GI tract
Wood dust	Group 1, 1995	Forest fires, in-air and burning	Nasal cavities and paranasal sinuses
PAHs ²	Group 2a, 1987	Formed during incomplete combustion of organic materials including diesel fuel	Studies have shown increased risk of lung, skin and bladder cancer with occupational exposure to PAH mixtures ³

¹ Group 1 – carcinogenic to humans; Group 2A – probably carcinogenic to humans; Group 2B – possibly carcinogenic to humans; Group 3 – not classifiable as to its carcinogenicity to humans; Group 4 – probably not carcinogenic to humans

² Individual Polycyclic aromatic hydrocarbons (e.g. benzo(a)pyrene, benzo(a)anthracene) have been classified as probably carcinogenic to humans (Group 2a) and many others have been classified as possibly carcinogenic (Group 2b) or not classifiable due to insufficient data (Group 3). Mixtures of PAHs (soot, have been classified as carcinogenic to humans (Group 1).

³ Boffeta et al., 1997

2.0 Objectives

Cancer Care Ontario was commissioned by the Policy and Regulation Development Bureau of the Workers' Compensation Board of British Columbia to undertake a project considering the association between the occupation of firefighting and certain cancers.

Specifically, the goal of this project is to synthesize and analyze the scientific/medical literature regarding the causal association between the occupation of firefighting and specific cancers. The cancers to be addressed are cancers of the brain, kidney, bladder, ureter, colon, testes, non-Hodgkin lymphoma, leukemia, lung cancer in non-smokers, and multiple myeloma.

3.0 Methods

3.1 Systematic Literature Search and Data Sources

In our search for relevant published literature we carried out a search of several electronic databases with the assistance of a librarian with expertise in electronic resources. Medline, EMBASE, CancerLit and CINAHL, were searched using the OVID interface and applying the following search string to identify exposures of interest: (“firefighter: or fire-fighter: or fire#n or fire m#n or fire fighter:” as key words or text words) or (occupational exposure (exploded) and fires (exploded)).

These results were combined with a search of neoplasms (exploded) as a keyword to identify the outcome of interest. The search was conducted for 1966 (the earliest year indexed in Medline) through December 2003. Although Medline and EMBASE returned the same number of citations, only half the citations retrieved through EMBASE were retrieved in Medline.

In addition, a search of the Web of Science was carried out for the years 1960 through October 2003 using the following search terms: (firefighter or fireman or firemen or fire fighter or fire-fighter) and (cancer or neoplasm or carcinoma). A bibliography of reports and articles provided by the Workers Compensation Board was reviewed and reference lists of relevant papers were manually searched.

Table 2: Summary of Search Strategy

Electronic Databases	Firefighter (and variations)	Occupational Exposures (exploded)	Firefighter or (Occupational Exposures and 'fire')	and Neoplasms (exploded)
Medline 1966 -	682	27299	732	52
EMBASE 1980 -	604	28849	775	52
CINAHL (Nursing Index) 1982 -	1153	3982	1157	2
HealthStar 1975 -	631	22747	647	50
Cancerlit 1975	65	4190	68	44
Web of Science 1960 – (includes Science Citation Index)	--	--	--	61

3.2 Inclusion and Exclusion Criteria

We included all English language studies which assessed the risk of cancer incidence or mortality among firefighters and which provided an estimate of risk in comparison to a non-firefighter population. Occupational surveillance studies which reported only significant positive associations between occupations and cancers or which report proportional mortality ratios based on death registrations were not included in the meta-analysis as the authors intend them to be a surveillance tool for identifying areas which warrant further study rather than an assessment of causal associations (Gallagher et al., 1989; Siemiatycki, 1991; NIOSH, 1997; Aronson et al., 1999).

A number of duplicate publications were found. If a study was updated to include additional years of enrolment or a longer period of follow-up, results from the most recent study were included. Publications which appeared to be reporting on the same study or the same outcomes for the same population were compared. In cases where studies overlapped in terms of study years and geographic region, the more comprehensive study was included. Three studies (Heyer et al., 1990; Rosenstock et al., 1991; Demers et al., 1992) reported on firefighters in the Seattle, Tacoma, Portland, Kent area. The study by Demers and colleagues (1992) was included as it reported on the longest period of follow-up for the same geographic area, excluding Kent, Bellevue (which comprised 151 of 4546 cases).

3.3 Data Extraction

Data on study design and results were extracted from all studies prior to carrying out the quality assessment. Data collected from cohort, case-control, and surveillance studies included:

- geographic region
- years of enrolment
- years of follow-up (cohort studies)
- study population, including age range, gender and race
- reference population
- exposure definition and data source
- cancer outcome and data source
- data available on other confounders
- adjustments in the main analysis
- number excluded or lost to follow-up
- number used in the analysis
- exclusion criteria
- minimum duration of employment

Information from individual studies are summarized in Appendix A.

Results were captured for each cancer site/group and analysis reported by the authors. Data captured for each outcome included:

- incidence or mortality outcome
- cancer sites and corresponding ICD codes
- effect measure (eg. Odds Ratio, Standardized Mortality Ratio)
- risk estimate
- confidence interval or p-value

Through the process of data collection, additional studies were found to be duplicates or found to not meet the inclusion/exclusion criteria and were subsequently excluded.

In total, data were extracted for 32 studies looking at risk of cancer among firefighters. Of these three were conducted in Canada, nineteen in the United States, two in Australia, three in New Zealand, and the remainder in Germany, France, Denmark, Sweden. One study did not specify the geographic region in which the firefighters were employed (Muscat & Wynder, 1995) but was likely conducted in the United States.

3.4 Quality Assessment

Quality assessment was carried out by four reviewers. Each article was reviewed by one scientist with expertise in the area of occupational and environmental epidemiology and one senior research associate. Articles were randomly distributed between reviewers and any discrepancies were discussed and resolved through consensus.

Reviewers independently assigned an overall rating to each study (weak, adequate or good). In addition, reviewers assessed and rated the studies on each of the dimensions of quality design, measurement, and analysis. The ratings of these three aspects were used to facilitate discussion during the consensus process. The classification of ‘weak’ was reserved for cases where there was thought to be high potential for bias based on methods described by the authors or cases where the study could not contribute data for specific cancer sites. Studies rated as ‘weak’ by both reviewers, or by consensus if there was disagreement, were eliminated from further analysis.

Through this process 15 studies were eliminated. A distribution of these studies by study design is shown in Table 3. The methods of each study are detailed in Appendix A.

Table 3: Quality Rating by Study Design

Quality Rating	Study Design			Total
	Cohort	Case-control	Surveillance	
Adequate/Good	13	5	0	18
Weak	4	6	5	15
Total	17	11	5	33

Table 4 summarizes the reasons for which studies were eliminated. Among the cohort studies, the following issues emerged: a relatively high proportion (20%) of firefighters in the cohort were lost-to-follow-up (Mastromatteo, 1959); estimates were reported for all cancers combined and not by cancer site (Mastromatteo, 1959; Deschamps et al., 1995); outcomes for firefighters were not measured in a manner consistent with the outcomes for the comparison population, i.e. classification was based on mention of cancer anywhere on the death certificate rather than the underlying cause (Lewis et al., 1982); and risk estimates were based on proportional mortality ratios (Feuer and Rosenman, 1986), the limitations of which are discussed below.

Table 4: Summary of Excluded Studies

	Quality of occupation data	High proportion missing occupation	High proportion lost to follow-up	Issues re: comparable exposure or outcome measures	Analysis used	Adjusted risk estimate not reported for specific cancer sites
Cohort Studies						
Deschamps, et al.						X
Feuer and Rosenman					PMR	
Lewis et al.				X		
Mastromatteo			X (20%)			X
Case-Control Studies						
Brownson, et al.	X (hosp rec)	X (38%)				
Figgs, et al.	X (dth certif)					
Krstev, et al.	X (dth certif)					
Muscat and Wynder						X
Sama, et al.	X (registry)	X (50%)				
Zahm, et al.	X (hosp rec)	X (48%)				
Other Designs						
Burnett, et al.	X (dth certif)				PMR	
Firth, et al.	X (registry)			X		
Ma, et al.	X (dth certif)				MOR	
Morton and Marjanovic	X (hosp rec)			X		
Grimes, et al.	X (dth certif)				PMR	

Two surveillance studies based on death certificates also used proportional mortality ratios (PMR) to estimate risk (Burnett et al., 1994, Grimes et al., 1991). Estimates calculated using a proportional mortality ratio are sensitive to the number of non-cancer deaths. Because these analyses are comparing the distribution of causes of death, a finding of an increased risk of cancer among firefighters as compared to the general population may in fact be reflecting a decreased risk of death from other non-cancer causes as compared to the general population. One large mortality study (Ma et al., 1998), in which the primary objective was to compare mortality of black and white firefighters, calculated mortality odds ratios (MOR) to estimate risk. The study was based only on data from death certificates and would be subject to similar limitations. In addition, occupation as listed on death certificates may be problematic and whether or not occupation is recorded may be related to factors such as age and duration of employment (Schade & Swanson, 1988; Schumacher, 1986; Steenland & Beaumont, 1984).

Among the case-control studies, a recurring issue was the quality of exposure data (ie. occupation). A number of studies used occupation as recorded on hospital charts or as reported to the cancer registry at time of diagnosis to determine exposure groups. A number of these studies report a high proportion of cases (38%-50%) for which occupation was missing and report that occupation was more often missing among older patients (Brownson et al., 1990; Sama et al., 1990; Zahm et al., 1989). As well, these case-control studies were not designed to look specifically at the risk of cancer among firefighters, but rather risk between various occupational groups and in some cases firefighters were analysed in a broader classification with police and other protective service workers.

While surveillance studies of this type can provide valuable information for hypothesis generation and identifying areas for further study, they are not strong designs for the purpose of assessing cancer risk.

3.5 Analysis

Following data extraction, cancer outcomes reported in each study were grouped into site groups based on ICD codes provided by the authors. In a few studies where ICD codes were not provided, classification was based on the terms used to describe the cancer site. Over twenty cancer sites and cancer site groups were reported in the literature. The text of the report discusses cancer sites which were specifically of interest. With one exception, studies did not report findings for ureter cancer specifically. A summary of results for cancer sites not discussed in the text may be found in Appendix B.

Calculating Pooled Estimates

The meta-analysis was carried out using Review Manager Software (Version 4.2) developed and made available by the Cochrane Collaboration Group (Review Manager, 2002; Clarke et al., 2002). Approaches for pooling data from studies looking at similar outcomes are designed for the analysis of data from randomized control trials. These methods are built on the assumption that the collection of studies are a sample of trials in which, through the process of randomization, the characteristics of the two groups are similar. In an RCT, the process of randomization controls for confounding. In an observational study, this must be done in the analysis. For this reason, the observational studies for which data are being pooled will need to have controlled for similar confounders.

Results for cancer incidence and mortality were analysed separately. Studies which reported both incidence and mortality were included in both analyses. Summary estimates were calculated for only those cancer sites having three or more studies within the group of incidence or mortality studies. In calculating the summary risk estimate, between-study source of variation was accounted for using a random-effects model (Fleiss, 1993).

Standard errors were calculated from 95% confidence intervals of the adjusted risk estimate using the following approximation:

$$\hat{SE}(\hat{q}) = \frac{\text{Log}(UL / LL)}{2(1.96)}$$

where, $\hat{q} = \text{Log}(\text{RiskEstimate})$

UL - upper confidence limit

LL - lower confidence limit

In cases where only a range for a p-value (eg. <0.05) was provided and there was insufficient data, standard errors could not be estimated. Standard errors were also not estimated for studies which observed no cases for a particular cancer. These studies will appear in the figures as ‘not estimable’. Confidence intervals calculated from the estimated standard error may in some cases differ from confidence intervals reported by the authors.

If any one study appeared to have a large influence (>50%) on the pooled estimate, the summary estimate was recalculated and the difference noted in the text. The influence of each study is graphically represented in the figures by the size of the marker representing the point estimate.

Combining Results for Colorectal Analysis

Data from each of seven cohort studies which reported results for sites of colon and rectum separately were combined to obtain an estimate for colorectal cancers. There is a high probability of misclassification between colon and rectal cancers, particularly as reported on death certificates. Studies looking at the accuracy of cancer mortality data, as listed on death certificates, have documented over reporting of colon cancer and underreporting of rectal cancer (Percy et al., 1981; Reynolds et al., 1991).

For each cohort study, observed and expected numbers were added for colon and rectum to obtain a combined ratio and 95% confidence intervals were calculated assuming a Poisson distribution as follows:

$$SMR / SIR = \frac{\sum obs(colon) + \sum obs(rectum)}{\sum exp(colon) + \sum exp(rectum)}$$

$$95\% CI = \exp(\log SMR \pm 1.96 \sqrt{\widehat{var}(\log SMR)})$$

$$\widehat{var}(\log SMR) = \frac{1}{obs}$$

3.6 Criteria for Conclusions

The conclusions for each cancer were based on the following set of criteria.

1. The amount of good quality data on which to base conclusions
 - At least 3 studies were required to generate a pooled estimate, not including studies that would have undue influence (>50%) on the pooled estimate. Because of potential differences between incidence and mortality studies with respect to quality of the diagnosis of disease, they were pooled separately.
 - Incidence data are given more weight because of the greater certainty around accuracy of diagnosis and the presence of disease. This is particularly true for cancers with good survival, where death can occur many years after diagnosis.
2. The consistency of the data
 - Confirmation of the association by different investigators and different studies
 - Pooled estimates for incidence and mortality studies point in the same direction
 - Sensitivity analyses do not qualitatively change the pooled estimate (eg. eliminating studies with fewer than 5 events for a cancer site)
3. The size of the estimated relative risk
 - Is it statistically significantly in excess of 1?
4. The evidence of carcinogenicity of work-related exposures
 - Is there good evidence that at least one substance to which firefighters might be exposed through work is carcinogenic to the specific cancer site?
5. The likelihood that study results are due to uncontrolled confounding or other methodological problems
 - Is it likely that the observed estimate of relative risk is the result of methodological limitations? That is,
 - a true occupation-related effect has been missed or
 - an observed effect is related to something other than occupation
6. The level of evidence of a dose-response relationship
 - Are there sufficient data available to assess a dose-response relationship? That is,
 - are there multiple studies with enough events to detect a trend of increase in risk with increasing exposure and
 - is there a reasonable measure of exposure (dose) in these studies
 - Do the available data provide evidence of a dose-response relationship?

Table 5: Table of Criteria for Conclusions

Conclusion	Criteria
Insufficient data to determine whether or not there is an increased risk associated with the occupation of firefighting	<ul style="list-style-type: none"> • Insufficient number of studies or no pooled incidence (I) estimate available
No evidence of increased risk associated with occupation of firefighting	<ul style="list-style-type: none"> • pooled estimates available for both I and mortality (M) studies • pooled estimates less than or close to 1 for both I and M studies (neither significantly in excess of 1) <p><i>and</i></p> <ul style="list-style-type: none"> • reasonable confidence that effects were not missed due to methodological issues (e.g., uncontrolled confounding; misclassification)
Limited evidence of increased risk associated with occupation of firefighting	<ul style="list-style-type: none"> • pooled estimates available for both I and M studies • pooled estimates >1 for both I and M, with borderline (or greater) significance for at least one of them <p><i>and</i></p> <ul style="list-style-type: none"> • at least one substance to which firefighters may be exposed at work is carcinogenic for this cancer site <p><i>and</i></p> <ul style="list-style-type: none"> • reasonable confidence that observed effects are not due to methodological issues (e.g., uncontrolled confounding, misclassification) <p><i>and</i></p> <ul style="list-style-type: none"> • insufficient data to evaluate a dose-response relationship
Sufficient evidence of increased risk associated with occupation of firefighting	<ul style="list-style-type: none"> • pooled estimates available for both I and M studies • pooled estimates >1 for both I and M, with borderline (or greater) significance for at least one of them <p><i>and</i></p> <ul style="list-style-type: none"> • at least one substance to which firefighters may be exposed at work is carcinogenic for this cancer <p><i>and</i></p> <ul style="list-style-type: none"> • reasonable confidence that observed effects are not due to methodological issues (e.g., uncontrolled confounding, misclassification) <p><i>and</i></p> <ul style="list-style-type: none"> • evidence of a dose-response relationship

4.0 Findings

The following sections summarize, by cancer site, findings of the systematic review of cancer risk among firefighters. For reasons discussed in the methods, some studies were eliminated prior to the meta-analysis.

A series of detailed tables summarizing results of individual studies by cancer site follows at the end of section 4.0. These tables show cancer site classifications and results as reported by the study authors. Standard errors used in the calculation of pooled estimates were based on an approximation as described in the methods. For this reason, 95% confidence intervals shown in the figures may be wider than those reported by the authors.

4.1 Bladder Cancer

Eight studies report results for bladder cancer incidence or mortality. Results of these studies are shown in Table 6 and results of the meta-analysis are shown in Figure 1. Incidence studies by Demers and colleagues (1994) and Bates and colleagues (2000) report slightly elevated risks of 1.20 (95%CI: 0.70, 1.90) and 1.14 (95%CI: 0.40, 2.70) in reference to the general population. As there were only two studies, a summary estimate was not calculated.

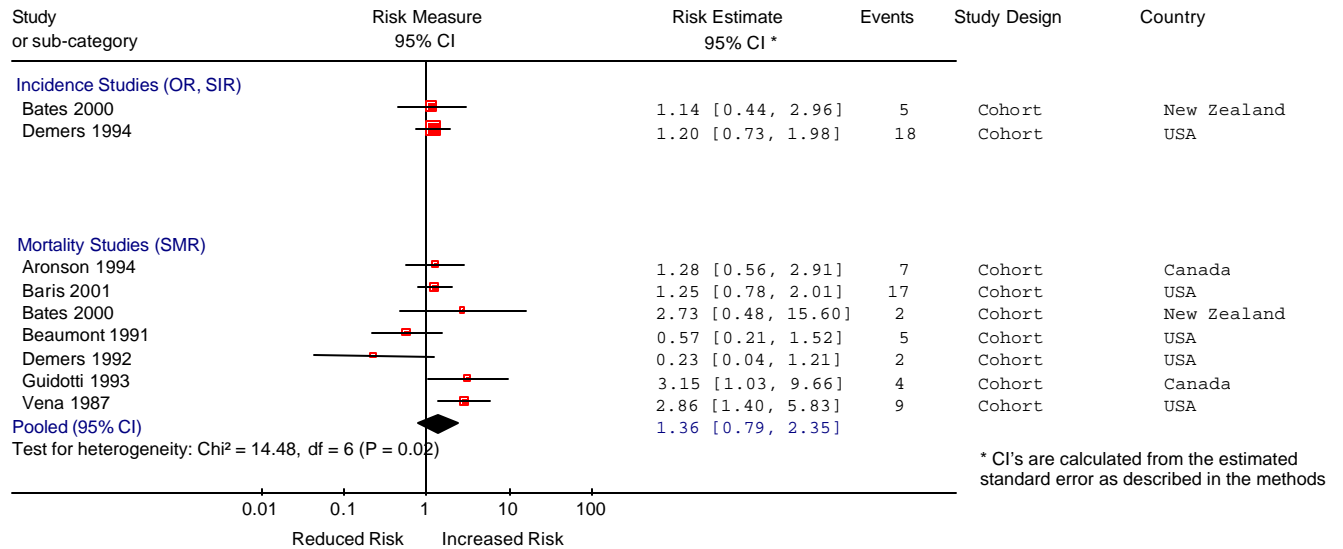
Of seven studies reporting mortality from bladder cancer, one study (Vena and Fiedler, 1987) reports a statistically significant increase of 2.86 (95%CI: 1.30, 5.40) and four studies report non-significant risk increases ranging from 1.25 (95%CI: 0.77, 2.00) to 3.15 (95%CI:0.86, 8.08). Beaumont and colleagues (1991) and Demers and colleagues (1992) report decreased risks of 0.57 (95%CI:0.21, 1.52) and 0.23 (95%CI:0.03, 0.83) respectively. The summary risk estimate is not significant at 1.36 (95%CI:0.79, 2.35).

Consistency of Findings

The two incidence studies report estimates which are similar in magnitude (1.14 and 1.20). The risk estimate for both studies was based on greater than five incidence cases. Studies of mortality, however, report estimates which vary from 0.23 to 3.15. Three of the seven mortality studies were based on fewer than five cases (Bates et al., 2000; Demers et al., 1992; Guidotti et al., 1993). Eliminating these studies did not qualitatively change the mortality summary risk estimate (1.34; 95%CI: 0.76, 2.36).

Two studies also report results using police as a reference population. Demers and colleagues (1994) report a non-significant increased risk of incidence among firefighters as compared to police officers employed in the same geographic region and during a the same time period (1.70; 95%CI: 0.70, 1.90). In a study of cancer mortality, Demers and colleagues (1992) report lower risk of mortality for firefighters as compared to police officers (0.16; 95%CI: 0.02, 1.24). The latter study was based on fewer than five cases.

Figure 1: Studies of Bladder Cancer among Firefighters



Dose-Response Analyses

The majority of studies which report dose-response analyses used duration of service as a surrogate for firefighter exposures. Three studies report analyses by duration of service in relation to bladder cancer. Analyses by Vena and Fiedler (1987) suggest a dose-response relationship but the numbers of cases are small. Baris and colleagues (2001) and Demers and colleagues (1994) did not find a relationship with duration of service. These data are presented in Table 7.

Risk Factors

Risk factors known to increase the risk of bladder cancer include tobacco smoking. An association with coffee consumption and artificial sweeteners has been suggested but findings have not been consistent (Schottenfeld & Fraumeni, 1996). Aside from age and gender (mainly by exclusion), potential confounders were not controlled for in these studies. Smoking is unlikely to be an important confounder given that studies have report smoking rates for firefighters which are similar to general population (Nelson et al., 1994), police officers (Brackbill et al., 1988; Stellman et al., 1988) or to other service and blue collar workers (Sama et al., 1990; Bates, 1987; Dibbs et al., 1982).

Increased risks for bladder cancer have been observed for dye workers and rubber workers, as well as workers exposed to high levels of PAHs (Boffetta et al., 1997; Silverman et al., 1992).

Conclusion and Interpretation

These studies taken together provide insufficient data to determine whether or not there is an increased risk of bladder cancer associated with the occupation of firefighting.

Given that there are only two incidence studies and that the results of mortality studies are inconsistent, additional incidence studies would be required to assess whether or not there is an association. Studies of incidence and mortality are considered separately as mortality studies may be reflecting factors related to treatment and survival.

4.2 Brain and Nervous System Cancers

Eleven studies report on the incidence of or mortality from brain and nervous system cancers. These studies are summarized in Table 8 and results of the meta-analysis are shown in the Figure 2. The four studies which looked at incidence of brain cancer, report increased risks ranging from 1.10 (95%CI: 0.30, 2.90) to 2.85 (95%CI: 0.77, 10.58). The pooled risk estimate for these four studies was not significant at 1.45 (95%CI: 0.84, 2.49).

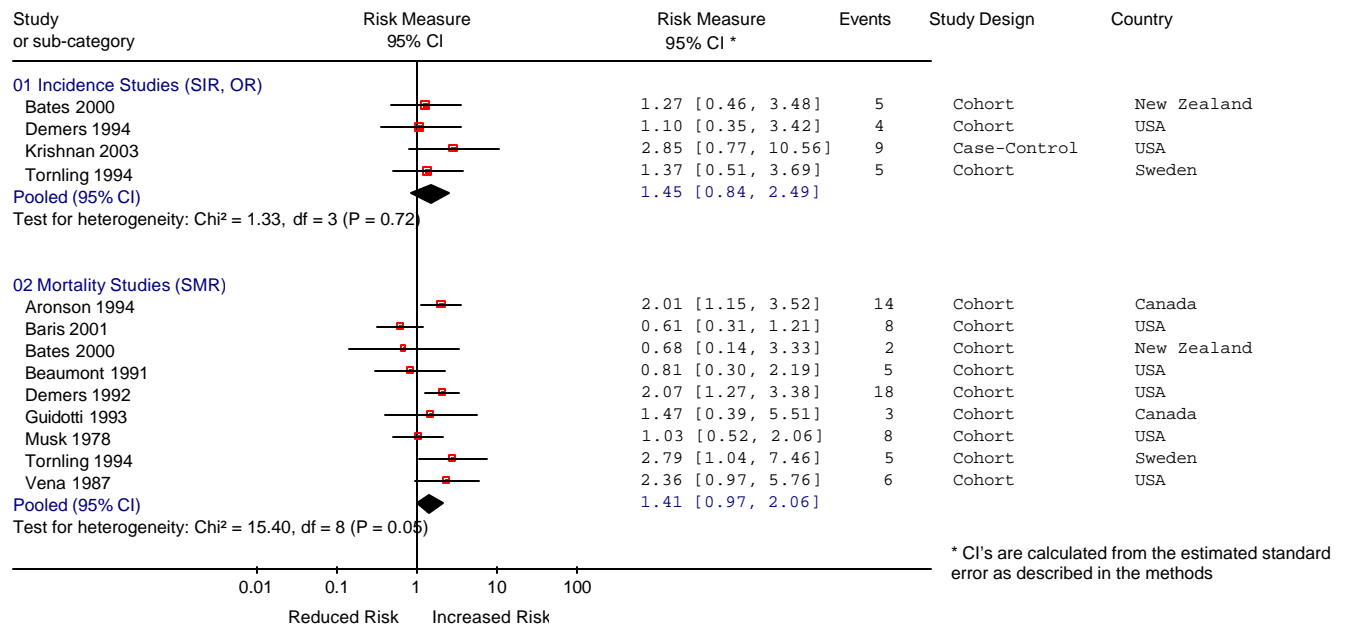
Of nine studies which report mortality from brain cancer, two report significant positive associations. Aronson and colleagues (1994) report an increased risk of 2.01 (95%CI: 1.10, 3.37). Demers and colleagues (1992) report a similar increase in risk of 2.07 (95%CI: 1.23, 3.28). Three mortality studies report non-significant increased risks ranging from 1.47 to 2.79 and three studies report non-significant decreased risks ranging from 0.81 to 0.61. Musk and colleagues (1978) report no association (1.03; 95%CI(estimated): 0.52, 2.06). The pooled risk estimate was of borderline significance at 1.41 (95%CI: 0.97, 2.06).

Consistency of Findings

The four incidence studies report estimates in the range of 1.10 to 2.85. Eliminating one incidence study (Demers et al., 1994) with fewer than five cases did not appreciably change the incidence summary estimate (1.57; 95%CI: 0.84, 2.92). Among the mortality studies, the estimates range from 0.61 to 2.79, with five of the eight studies reporting elevated risks. Eliminating two mortality studies (Bates et al., 2000; Guidotti, 1993) with fewer than five cases did not appreciably change the mortality summary estimate (1.55; 95%CI: 0.96, 2.51).

Two studies also report results in comparison to police officers employed in the same geographic region. Demers and colleagues (1994) report a higher risk of incidence among firefighters as compared to police officers (1.40; 95%CI: 0.20, 11.0). Similarly, in a second study Demers and colleagues (1992) report a non-significant increased risk of mortality from brain cancer for firefighters as compared to police officers (1.63; 95%CI: 0.70, 3.79).

Figure 2: Studies of Brain and Central Nervous System Cancers among Firefighters



Dose-Response Analyses

Analyses by duration of service are reported in seven studies. These data are shown in Table 9. Although none of the studies identified a significant dose-response relationship, there is some suggestion of an increased risk with longer duration of service. Demers and colleagues (1992) report a significantly increased risk of 3.53 (95%CI: 1.5-7.0) for individuals with 10-19 years of service. Tornling and colleagues (1994) report increased risk with increasing duration of service for both incidence and mortality, although neither was statistically significant. Tornling and colleagues also report analyses using number of calls per firefighter as a surrogate for exposure. In this analysis, a significantly increased risk of mortality was seen for those in the highest exposure category (4.96, 95%CI: 1.35, 12.70).

Risk Factors

Cancers of the brain and nervous system are not common as compared to other cancers and prognosis is poor. The etiology of brain tumours is not well understood. Risk factors include genetics and possibly ionizing radiation. Aside from age and gender (mainly by exclusion), potential confounders were not controlled for in these analyses.

The majority of cases with known morphology are reported to be gliomas, which have been associated with exposure to vinyl chloride. Formaldehyde and acrylonitrile have also been associated with brain cancers. These are agents to which firefighters may potentially be exposed. Increased risk of brain and nervous system cancers have been observed for workers in the rubber and petrochemical industries (Inskip et al., 1995; Schottenfeld & Fraumeni, 1996).

Conclusion and Interpretation

These studies taken together provide limited evidence of an increased risk of brain cancer associated with the occupation of firefighting.

The main limitations of the studies assessing risk of brain cancer among firefighters include small numbers of cases resulting in low statistical power, limited data for analysis of a dose-response relationship, and lack of data on individual exposures.

4.3 Colorectal Cancer

Three studies report on the occupation of firefighting and incidence of (Giles et al., 1993) or mortality from (Eliopoulos et al., 1984; Guidotti, 1993) colorectal cancers. In addition, three incidence studies and seven mortality studies report results for the sites of colon and rectum separately. Given that studies have reported a high chance for misclassification, colon and rectal cancers are often considered in combination. This is true for cause of death listed on death certificates where studies have documented over reporting of colon cancer and underreporting of rectal cancer (Percy et al., 1981; Reynolds et al., 1991). Results for these studies were combined, as described in the methods, and included in the colorectal meta-analysis. Data for colon and rectal cancers are also presented separately, however, pooled estimates were not calculated for mortality.

Colorectal findings from incidence and mortality studies are shown in Table 10 and presented in the following figure. Of four incidence studies, three report a non-significant increased risk (Giles et al., 1993; Demers et al., 1994; Tornling et al., 1994) and one reports a non-significant decreased risk (Bates et al., 2000). The summary risk estimate for all four incidence studies combined was not significant at 1.08 (95% CI: 0.86, 1.35).

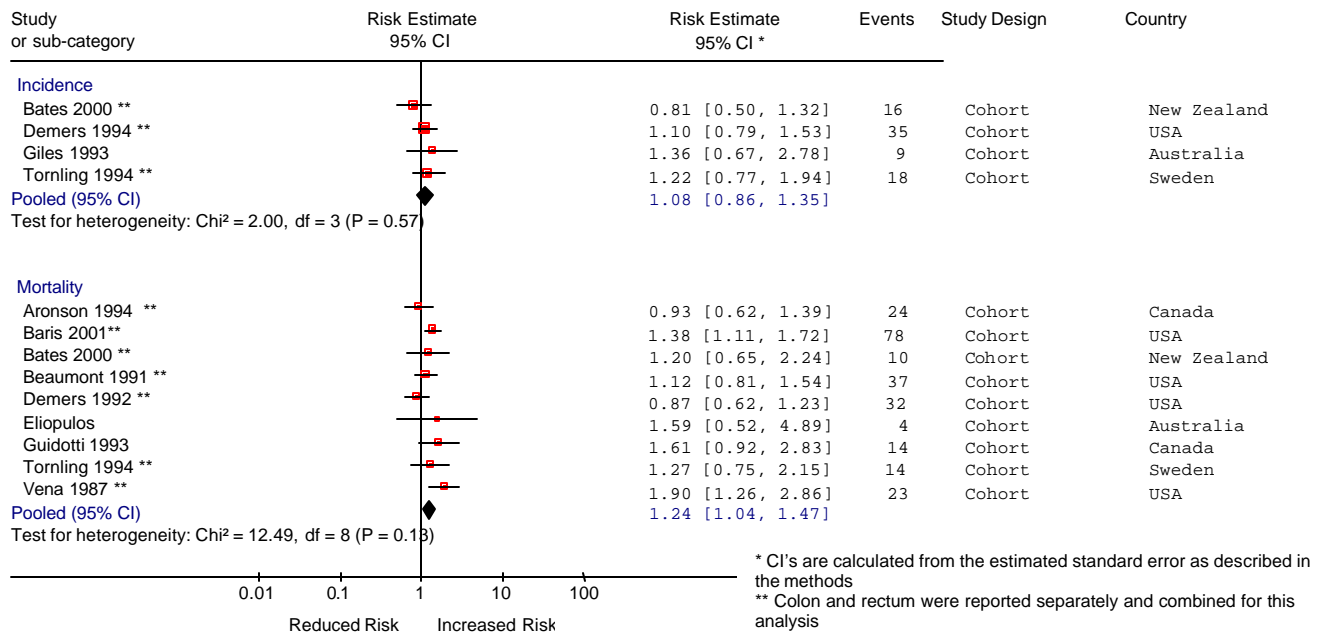
Of nine studies looking at mortality outcomes, Vena and colleague and Baris and colleagues report significantly increased risks of 1.90 (95%CI: 1.26, 2.86) and 1.38 (95%CI: 1.11, 1.72) respectively. Five studies report non-significant increased risks (Eliopoulos et al., 1984; Beaumont et al., 1991; Guidotti, 1993; Tornling et al., 1994; Bates et al., 2000) and two report non-significant decreased risks (Demers et al., 1992; Aronson et al., 1994). The summary risk estimate for these nine mortality studies was significant at 1.24 (95%CI: 1.04, 1.47).

Consistency of Findings

Estimates ranging from 0.81 to 1.36 for studies of cancer incidence are consistent with the estimates ranging from 0.87 to 1.90 from the nine mortality studies. The risk estimates for all incidence studies were based on five or more cases. Eliminating one mortality study with fewer than 5 events (Eliopoulos et al., 1984) did not appreciably change the mortality summary estimate (1.23; 95%CI: 1.02, 1.48).

As shown below, the summary estimate for studies reporting incidence of colon cancer was not significant at 0.97 (95% CI: 0.69, 1.36). The summary risk estimate for studies reporting incidence of rectal cancer was increased but not significant at 1.25 (95%CI: 0.84, 1.85). In comparison to police officers, Demers and colleagues (1994) report incidence density ratios of 1.30 (95%CI: 0.60, 3.00) for colon cancer and 1.30 (95%CI: 0.50, 3.90) for rectal cancer. Misclassification between colon and rectal cancers is less likely to be a concern for studies of cancer incidence.

Figure 3: Studies of Colorectal Cancer among Firefighters



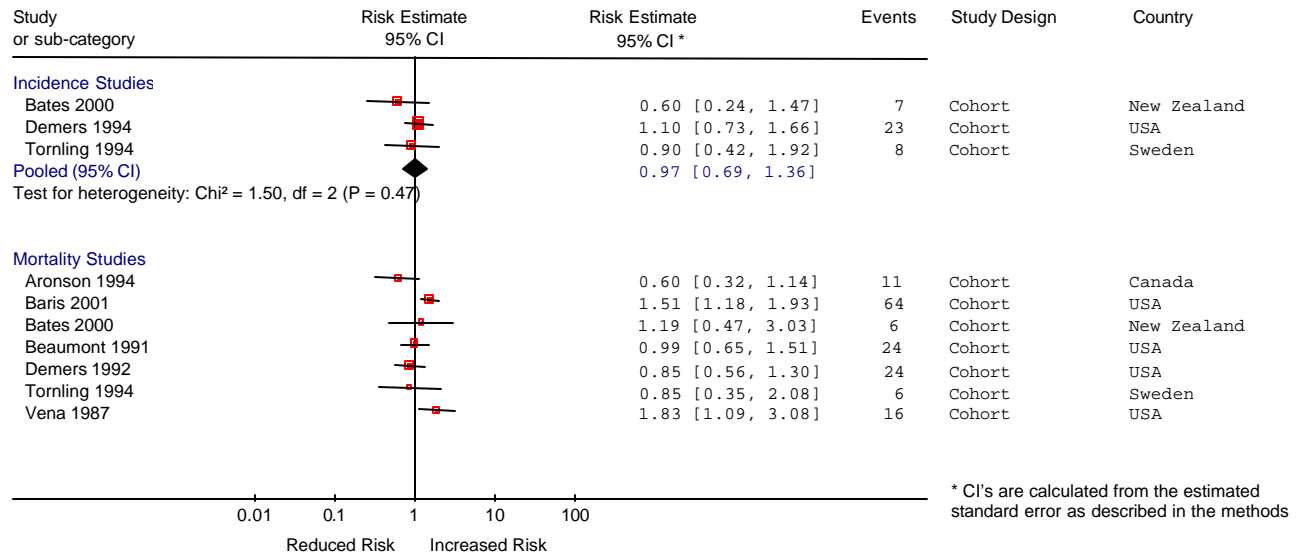
Colon Cancer

Eight studies report on the association between incidence of or mortality from colon cancer and firefighting. These studies were included in the colorectal analysis. Results of these studies are summarized in Table 11. Among the studies of cancer incidence, one report a decreased risk which was not significant (Bates et al., 2000) and two found no association (Demers et al., 1994; Tornling et al., 1994). The summary risk estimate for three studies of incidence of colon cancer was not significant at 0.97 (95% CI: 0.69, 1.36). All three studies were cohort studies which calculated standard incidence ratios (SIR's) in reference to a general male population.

Of the seven studies looking at mortality, two report significant positive associations (Baris et al., 2001; Vena and Fiedler, 1987) and one reports a non-significant positive association (Bates et al., 2000). Three report fewer than expected cases (Demers et al., 1992; Aronson et al., 1994; Tornling et al., 1994) and one reports no association (Beaumont et al., 1991). All seven studies

were cohort studies which report SMRs in relation to a general male population. A meta-analysis of mortality from colon cancer was not done for reasons discussed earlier.

Figure 3a: Studies of Colon Cancer among Firefighters

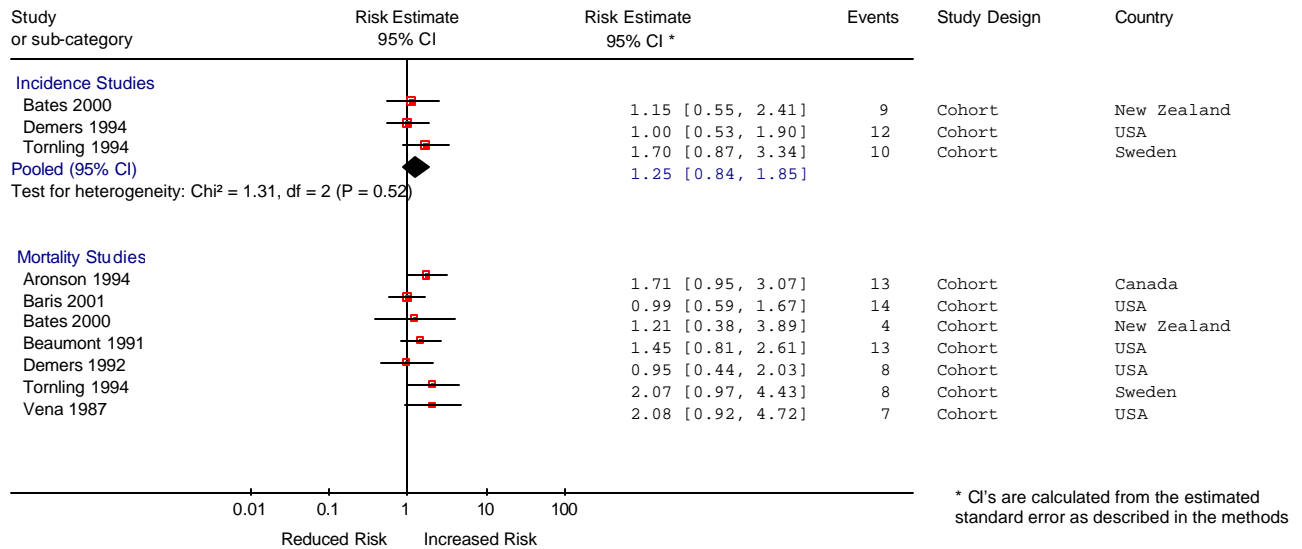


Rectal Cancer

Eight studies report on the risk of rectal cancer among firefighters. These studies were included in the colorectal analysis. Of the three cancer incidence studies, Tornling and colleagues (1994) report a non-significant risk increase of 1.70 (95%CI:0.81, 3.12), Bates and colleagues (2000) report a weak increased risk of 1.15 (94%CI: 0.50, 2.20) and Demers and colleagues (1992) report no association. A pooled risk estimate was not significant at 1.25 (95%CI: 0.84, 1.85).

Of seven studies which report mortality outcomes, five report non-significant increases in risk ranging from 1.21 (95%CI: 0.30, 3.10) to 2.08 (95%CI: 0.83, 4.28) and two report no evidence of an association (Demers et al., 1992; Baris et al, 2001). A meta-analysis of mortality from rectal cancer was not done for reasons discussed earlier.

Figure 3b: Studies of Rectal Cancer among Firefighters



Dose-Response Analyses

The majority of studies which report a dose-response analysis used duration of service as a surrogate measure of exposure. Analysis by duration of service was not reported in any of the three studies which report results for colorectal cancer (Giles et al., 1993; Eliopoulos et al., 1984; Guidotti, 1993).

Among studies which report results for colon cancer and rectal cancer and which also report analyses by duration of service, there was no clear evidence of a relationship with duration of service. Duration of service analyses for colon cancer are shown in Table 12. Demers and colleagues (1994) and Bates and colleagues (2000) were able to report these analyses for incidence studies and found a weak association with increasing duration of service. Among the six mortality studies, there was no clear evidence of a relationship with duration of service (Bates et al., 2000; Baris et al., 2001; Beaumont et al., 1991; Vena and Fiedler, 1987; Demers et al., 1992; Demers et al., 1994).

Duration of service analyses for rectal cancer studies are shown in Table 14. Two incidence studies and three mortality studies report analyses by duration of service. There is no suggestion in these studies of an increased risk of rectal cancer with longer duration of employment.

Risk Factors

Apart from age, factors associated with risk of colorectal cancer (such as family history, diet, obesity, long-term tobacco smoking, and physical inactivity) were not controlled for in these

studies. Few studies have compared the characteristics of firefighters to those of the general population. Glueck and colleagues (1996) report that firefighters in their study were, on average, heavier than the NHANES I working male participants but had, on average, normal lipid and blood pressure profiles. Dibbs and colleagues (1982) report that among white male participants in the Normative Aging Study, baseline body mass index and serum cholesterol were similar for firefighters and non-firefighters.

Although colorectal cancers have not generally been associated with occupational exposures, it is an area which is receiving greater attention. There is evidence of an association between asbestos exposure and increased risk of cancers of the colon and rectum (IARC, 1987; Homa et al., 1994; Goldberg et al., 2001). In a study of occupational exposure to inorganic dusts, Siemiatycki and colleagues (1989) report an increased risk for colon cancer among workers exposed to concrete dust, in which free silica is often found. Similar to asbestos exposure, an increased risk was found for short periods of exposure. In a related study, Gérin and colleagues (1998) report limited evidence of increased risk for colon and rectal cancer among workers exposed to monocyclic aromatic hydrocarbons (xylene, toluene, styrene). Gerhardsson and colleagues (1992) report increased risks for colon cancer among male Swedish workers exposed to soot and asbestos. Increased risks for rectal cancer were reported for workers exposed to soot, combustion gases from coal/coke/wood, and asbestos. These exposures were highly correlated.

Conclusion and Interpretation

These studies taken together provide limited evidence of an increased risk of colorectal cancer associated with the occupation of firefighting.

The main limitations of these studies include limited data with which to assess a dose-response relationship, limited or no data available on confounders, and limited exposure indices.

4.4 Kidney Cancer

Ten studies report results for incidence of or mortality from kidney cancer. Cancer incidence was reported in three cohort studies and one case-control study. Delahunt and colleagues (1995) report a significantly increased risk of 3.51 (95%CI: 2.09, 5.92). Three cohort studies report non-significant risk reductions of 0.36 (95%CI: 0.04, 1.29), 0.50 (95%CI: 0.10, 1.60) and 0.57 (95%CI: 0.10, 2.10). The pooled estimate was not significant at 0.89 (95%CI: 0.23, 3.39).

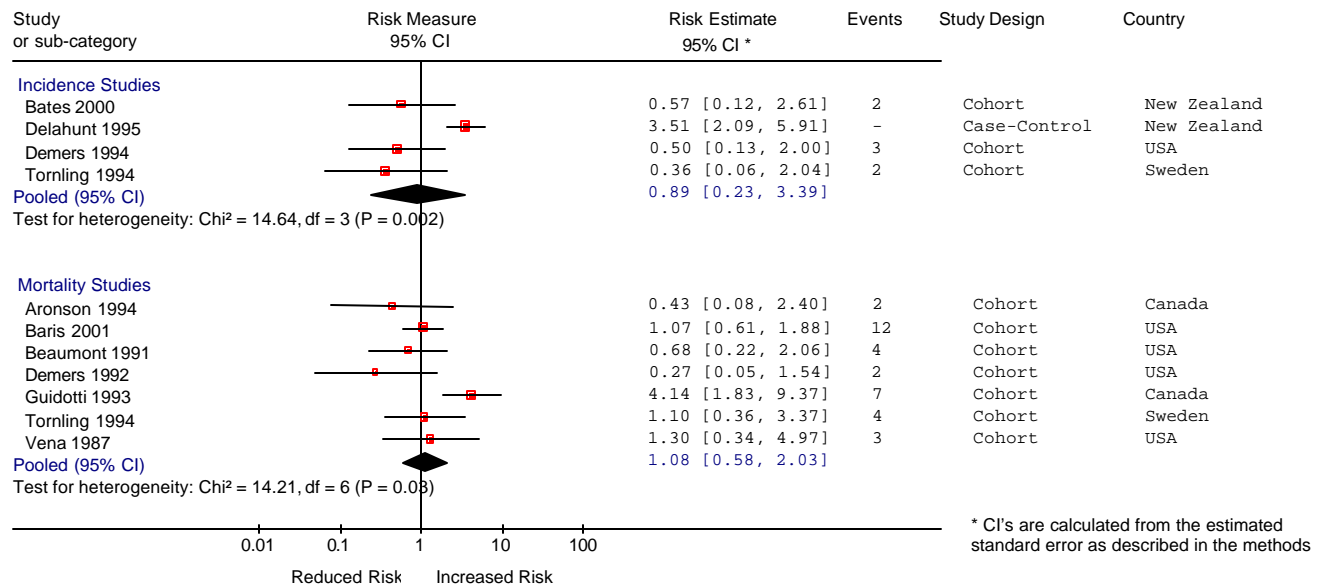
Seven studies report mortality outcomes. Guidotti and colleagues (1993) report a significant increase of 4.14 (95%CI: 1.66, 8.53) and Vena and colleagues (1987) report an elevated but not significant increase of 1.30 (95%CI: 0.26, 3.80). Three studies by Aronson (1994), Beaumont (1991) and Demers (1992) report reduced risks. The two remaining studies by Tornling and colleagues (1994) and Baris and colleagues (2000) did not report an association. The summary estimate is not significant at 1.08 (95%CI: 0.58, 2.03).

Consistency of Findings

Three of four incidence studies report estimates ranging from 0.36 to 0.57. The fourth, a case control study, reports an estimate of 3.51. Similarly, a wide range of estimates is reported among the mortality studies, with one study reporting an estimate of 4.14 and the remaining ranging from 0.27 to 1.30. Three of the four incidence studies were based on fewer than five cases. The remaining study, a case control study, did not report the number of kidney cancer cases on which the analysis was based. Eliminating these studies would have resulted in insufficient data to generate a summary estimate. Eliminating five mortality studies (Beaumont et al., 1991; Aronson et al, 1994; Demers et al., 1992; Tornling et al., 1994; Vena & Fiedler, 1987) which are based on fewer than five kidney cancer cases would leave only two mortality studies. A summary risk estimate was not recalculated.

Using police officers as a comparison population, Demers and colleagues (1994) report a lower risk of kidney cancer among firefighters as compared to police officers (0.40; 95%CI: 0.10, 2.10), although this was not statistically significant.

Figure 4: Studies of Kidney Cancer among Firefighters



Dose-Response Analyses

Two studies report analyses by duration of service. These results may be found in Table 16. Guidotti and colleagues (1993) report that six of seven deaths occurred among firefighters employed for 20 years or longer. Of 12 deaths due to kidney cancer, Baris and colleagues (2001) report two occurred among firefighters with fewer than 10 years of employment and 10 occurred among firefighters with greater than 20 years of service.

Risk Factors

Risk factors related to kidney cancer include cigarette smoking and obesity (Schottenfeld & Fraumeni, 1996). Aside from age, potential confounders were not controlled for in the cohort studies. Additional confounders were available in a case control study by Delahunt and colleagues (1995), who report a similarly elevated risk when stratified by smoking history. Increased risks of kidney cancer have been observed in petroleum-based occupations.

Conclusion and Interpretation

These studies taken together provide no evidence of an increased risk of kidney cancer associated with the occupation of firefighting.

4.5 Leukemia

Five studies report findings for incidence of or mortality from leukemia. These results may be found in Table 17. Results of the meta-analysis are shown in Figure 5. The two incidence studies (Giles et al., 1993; Demers et al., 1994) report no association in reference to the general population.

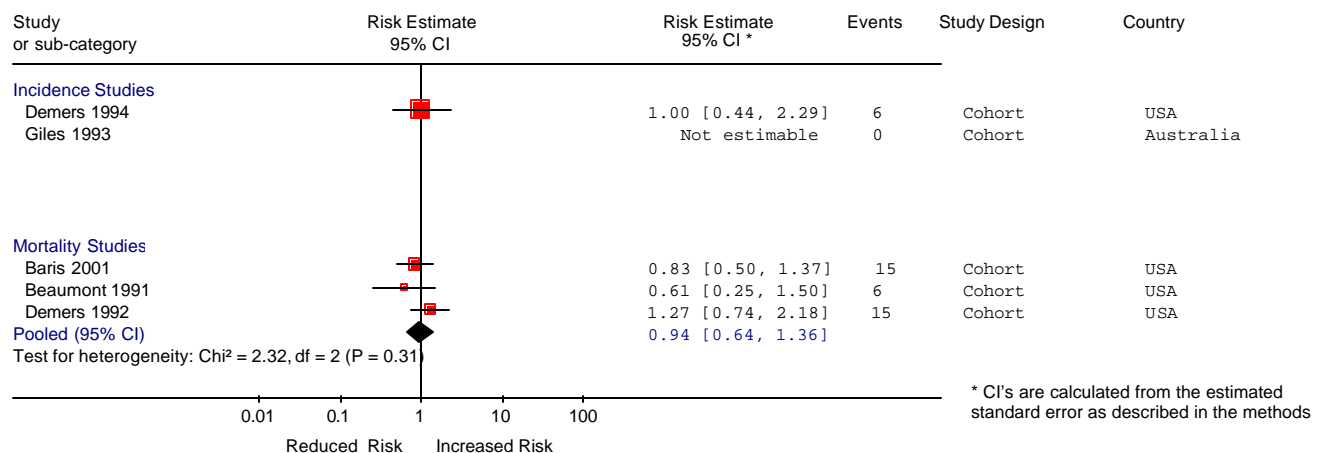
Of three studies which report cancer mortality, one (Demers et al., 1992) reports a non-significant increased risk of 1.27 (95% CI: 0.71, 2.09) and two report non-significant decreased risks of 0.83 (95% CI: 0.50, 1.37) and 0.61 (95% CI: 0.22, 1.33). The summary risk estimate is not significant at 0.94 (95% CI: 0.64, 1.36).

Consistency of Findings

Of two incidence studies, one observed no cases of leukemia (Giles et al., 1993) and the second reports a risk estimate of 1.00. The three mortality studies report estimates ranging from 0.61 to 1.27. All the studies of mortality were based of five or more cases.

In comparison to police officers, Demers and colleagues (1994) report a non-significant decreased risk for incidence of leukemia (0.80; 95% CI: 0.20, 3.50). In a second study, Demers and colleagues (1992), who report a non-significant increased risk in comparison to the general population, report a non-significant decreased risk of mortality (0.80; 0.38, 1.70) in comparison to police officers.

Figure 5: Studies of Leukemia among Firefighters



Dose-Response Analyses

Three studies report results by duration of service and these data are shown in Table 18. Demers and colleagues (1992) report an increased risk of 2.60 (95% CI: 1.0, 5.4) for individuals with 30

years of employment or more. Baris and colleagues (2001) and Demers and colleagues (1994) did not detect an association with duration of employment.

Risk Factors

Leukemia is a heterogeneous group of diseases, of which the subtypes may have differing etiologies. Leukemia has been associated with ionizing radiation and genetics. Other risk factors, such as smoking, have not been well established (Schottenfeld & Fraumeni, 1996).

Leukemia has been associated with exposure to benzene, formaldehyde, styrene, 1-3 butadiene, and vinyl chloride. Firefighters have the opportunity for exposure to all these agents. Studies have reported concentrations of benzene and formaldehyde at structural fires which exceed NIOSH or ACGIH ceiling or short-term exposure levels. Increased risks of leukemia have been observed among workers employment in rubber and petroleum industries.

Conclusion and Interpretation

These studies taken together provide insufficient data to determine whether or not there is an increased risk of leukemia associated with the occupation of firefighting.

4.6 Lung Cancer

Ten studies report on the association between firefighting and lung cancer incidence or mortality. Results of these studies are shown in Table 19 and results of the meta-analysis are shown in Figure 6. Of four studies looking at cancer incidence, non-significant reductions in risk were reported by Giles and colleagues (1993) (0.77, 95%CI: 0.28, 1.68) and Tornling and colleagues (1994) (0.89, 95%CI: 0.51, 1.45). Two other studies (Demers et al., 1994; Bates et al., 2000) found no evidence of an association or only slightly elevated risks. The summary risk estimate was not significant at 0.99 (95%CI: 0.79, 1.24). Combined, these studies represent 84 cancer cases among firefighters in New Zealand, Australia, Sweden and the United States.

Eight studies report results of mortality from lung cancer. Of these, Hansen and colleagues (1990) report a non-significant increased risk of 1.42 (95%CI: 0.91, 2.11) and Guidotti (1993) reports a non-significant increased in risk of 1.63 (95%CI: 0.75, 3.10). Baris and colleagues (2001) report a slightly elevated risk of 1.13 (95%CI: 0.97, 1.32). The remaining two studies (Beaumont et al., 1991; Bates et al., 2000) report non-significant decreases of 0.84 (95%CI: 0.64,1.08) and 0.86 (95%CI: 0.40, 1.60). The summary risk estimate was not significant at 1.02 (95%CI: 0.91, 1.15).

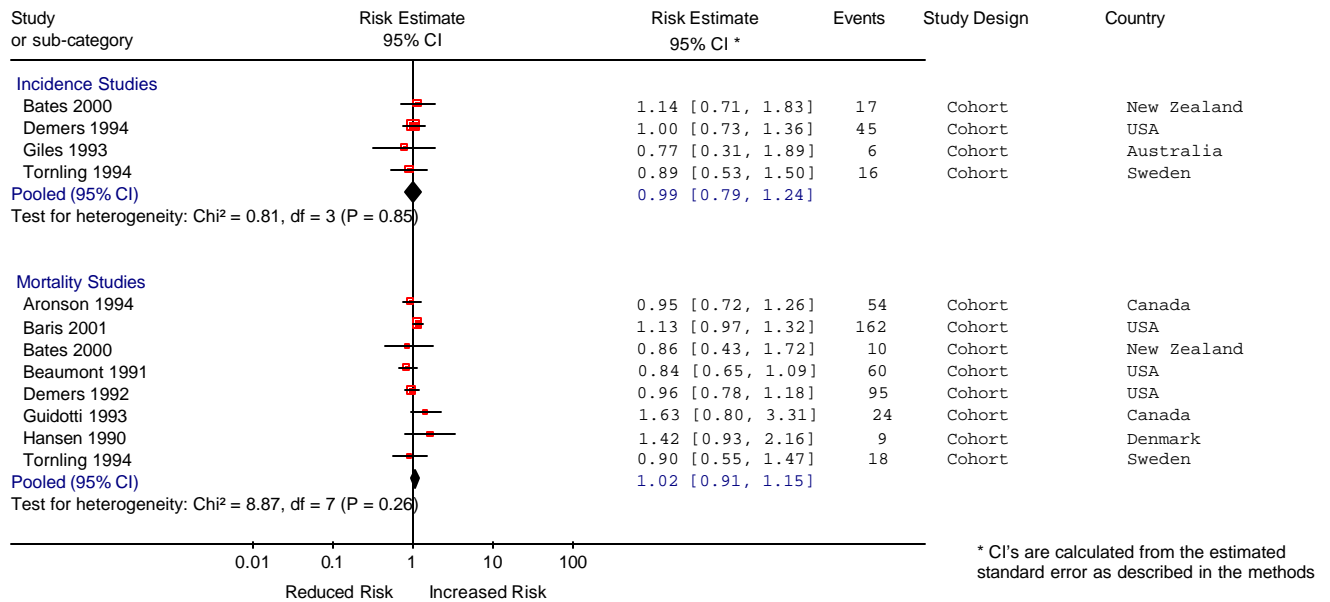
Consistency of Findings

The four incidence studies report estimates ranging from 0.77 to 1.14. This is similar in magnitude to estimates reported by mortality studies, with six estimates falling in the range of 0.84 to 1.13 and two studies reporting estimates of 1.42 and 1.63. All the studies of lung cancer incidence or mortality were based on five or more cases. Including three mortality studies which

report results for respiratory system cancers as a group (Eliopoulos et al., 1984; Musk et al., 1978; Vena & Fiedler, 1987) did not appreciably change the mortality summary risk estimate (1.00; 95%CI: 0.91, 1.09).

Two studies report results using police as a reference population. Demers and colleagues (1994) report a similar risk of lung cancer mortality among firefighters as compared to police officers (1.10; 95%CI: 0.60, 1.90). Similarly, in a study of cancer incidence, Demers and colleagues (1992) report risk of bladder cancer mortality among firefighters to be similar to that of police officers (0.95; 95%CI: 0.67, 1.33).

Figure 6: Studies of Lung Cancer among Firefighters



Dose-Response Analyses

In total, seven studies report additional analyses by duration of service. These data are shown in Table 20. None of the studies, including the largest (Baris et al., 2001), found a relationship with increasing years of service.

Risk Factors

Aside from age, these studies were not able to control for potential confounders, the most important of which is smoking. Studies have reported smoking rates among firefighters that are similar to those of the general population (Nelson et al., 1994), police officers (Brackbill et al., 1988; Stellman et al., 1988,) or other blue collar workers (Sama et al., 1990; Bates 1987, Dibbs et al., 1982).

A number of agents to which firefighters may be exposed, including PAHs, asbestos, vinyl chloride, diesel exhaust and formaldehyde, have been associated with increased risk of lung cancer. In a review of occupational exposure to PAHs, Boffetta and colleagues (1997) report an increased risk of lung cancer for occupations with high exposure to mixtures of PAHs.

Conclusion and Interpretation

These studies taken together provide no evidence of an increased risk of lung cancer associated with the occupation of firefighting.

Despite the potential for exposure to a number of agents which have been linked to risk of lung cancer, an increased risk was not seen among firefighters. The risk estimates reported by studies of cancer in firefighters are remarkably similar. Given that smoking rates among firefighters are reported to be similar to those of blue collar workers and the general population, we would not expect the baseline risk of lung cancer to be lower than that of the general population.

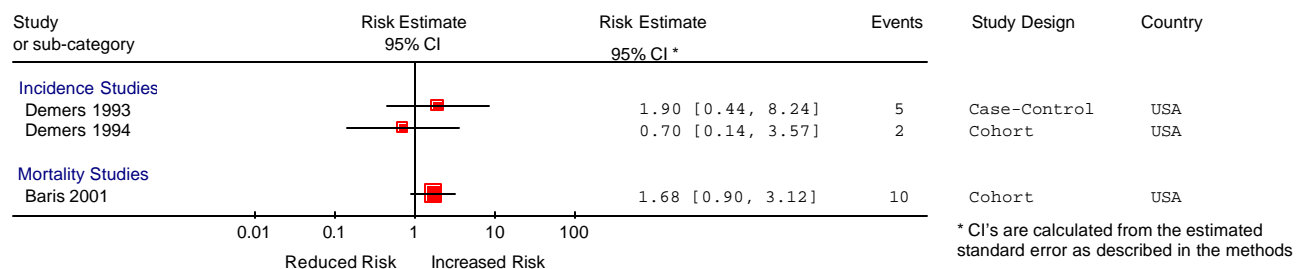
4.7 Multiple Myeloma

Three studies reported on incidence of or mortality from multiple myeloma. Data from these studies may be found in Table 21. Demers and colleagues (1994) report a reduction in risk of 0.70 (95%CI: 0.10, 2.60) for a cohort of firefighters in Seattle and Tacoma. In a case-control study, Demers and colleagues (1993) report a non-significant increase of 1.90 (95%CI: 0.50, 9.40). The third study, a mortality study by Baris and colleagues (2001), reports an increased risk of 1.68 (95%CI: 0.90, 3.11).

Consistency of Findings

The two incidence studies report risk estimates which range from a decreased risk of 0.70 to an increased risk of 1.90. The study reporting a decreased risk (Demers et al., 1994) was based on fewer than five cases. One mortality study reports an estimate of 1.68. This study was based on greater than five cases. There were no studies which reported risk estimates using police officers as a reference population.

Figure 7: Studies of Multiple Myeloma among Firefighters



Dose-Response Analyses

Two studies (Demers et al., 1993; Baris et al., 2001) report analyses by duration of employment. These data may be found in Table 22. There is a suggestion of increased risk with increasing years of employment although the numbers in both studies are small. Baris and colleagues report a significant mortality risk increase of 2.31 (95% CI: 1.04, 5.16) for those employed 20 years or more. Demers and colleagues report an elevated risk of 2.90 (95% CI: 0.4, 21.6) among those employed 10 years or more although this was not significant.

Risk Factors

Non-occupational risk factors for multiple myeloma have not been well established (Schottenfeld & Fraumeni, 1996). Multiple myeloma has been associated with exposure to benzene, engine exhaust, ionizing radiation. Benzene, found in varying quantities in nearly all fires, has been recorded at levels in excess of recommended short-term and ceiling exposure levels.

Conclusion and Interpretation

These studies taken together provide insufficient data to determine whether or not there is an increased risk of multiple myeloma associated with the occupation of firefighting.

4.8 Non-Hodgkin Lymphoma

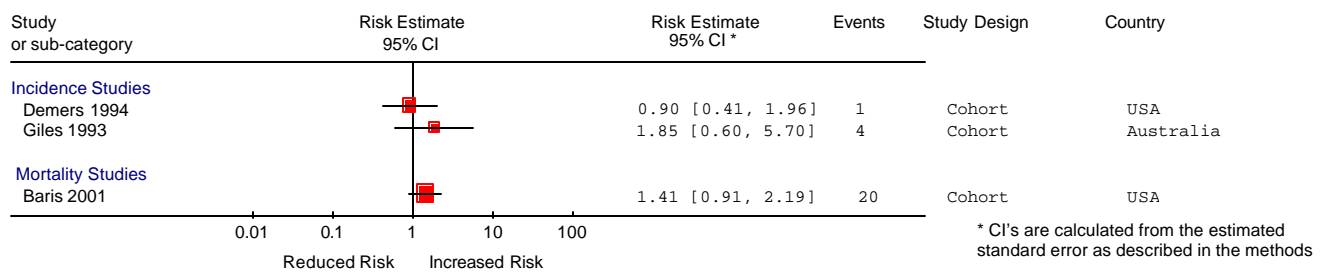
Three studies report on the risk of non-Hodgkin lymphoma among firefighters. Of these, two studies report findings for cancer incidence. Demers and colleagues (1994) report a non-significant decreased risk of 0.90 (95%CI:0.40, 1.90) and Giles and colleagues (1993) report a non-significant increased risk of 1.85 (95%CI:0.50, 4.74). In a mortality study, Baris and colleagues (2001) report a non-significant increased risk of 1.41 (0.91, 2.19).

Consistency of Findings

Two incidence studies report risk estimates of 0.90 and 1.85. Both estimates were based on greater than five cases. One mortality study reports a risk estimate within this range at 1.41. This study also calculated a risk estimate based on greater than five cases.

One study was able to report results using police officers as a reference population. Demers and colleagues (1994) report a non-significant increased risk of 1.80 (95%CI: 0.40, 13.0) for firefighters as compared to police officers.

Figure 8: Studies of Non-Hodgkin Lymphoma Cancer among Firefighters



Dose-Response Analyses

Two studies report analyses by duration of service (Demers et al., 1994; Baris et al., 2001). Neither study reports a dose-response relationship.

Risk Factors

The etiology of non-Hodgkin lymphoma is not well understood. Inherited and acquired immune disorders and ionizing radiation have been tied to increased risk. Increased risk has been observed among workers in the agricultural industries. Occupational exposures which have been associated with increased risk of lymphoma include benzene, a carcinogen to which firefighters are exposed.

Conclusion and Interpretation

These studies taken together provide insufficient data to determine whether or not there is an increased risk of non-Hodgkin lymphoma associated with the occupation of firefighting.

4.9 Testicular Cancer

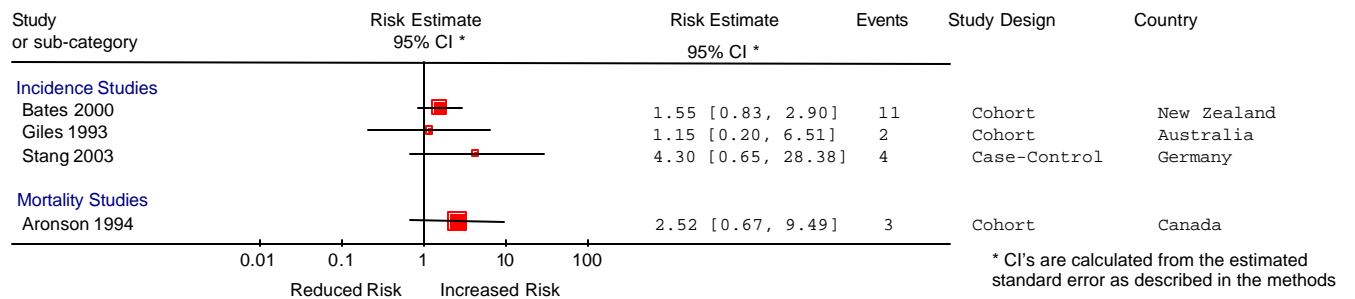
Three studies report results for incidence of testicular cancer. Two cohort studies by Bates and colleagues (2000) and Giles and colleagues (1993) report non-significant elevated risks of 1.55 (95%CI:0.80, 2.80) and 1.15 (95%CI: 0.13, 4.17) respectively. As well, in a case-control study, Stang and colleagues report an elevated risk of 4.30 (95%CI: 0.70, 30.5). These estimates did not reach statistical significance. Pooled estimates are not presented since one study (Bates et al., 2000) of three would carry considerable influence (greater than 50% as represented by the relative size of the marker on the point estimate) and the estimate would essentially reflect findings of this one study.

In a cohort study of Toronto firefighters, Aronson and colleagues (1994) report an increased risk of mortality from testicular cancer of 2.52 (95%CI: 0.52, 7.37).

Consistency of Findings

The risk estimates reported by three incidence studies range in magnitude from 1.15 to 4.30, with the highest estimate being reported by a case control study. Two of the three studies were based on fewer than five cases (Stang et al., 2003; Giles et al., 1993). The estimate of the mortality study, at 2.52, falls within the range of these studies.

Figure 9: Studies of Testicular Cancer among Firefighters



Dose-Response Analyses

Of three studies which report analyses by duration of service, two did not show a dose-response relationship; however, there is some suggestion of an increase in risk with increasing duration of employment in the study by Bates and colleagues (2000). These data are presented in Table 26.

Risk Factors

The most established risk factor for testicular cancer, an undescended testicle, is present in only a small percent of the population and would not constitute a major confounder. The case control study by Stag and colleagues, which reports an increased risk, was able to control for both this and family history of testicular cancer.

Conclusion and Interpretation

These studies taken together provide insufficient data to determine whether or not there is an increased risk of testicular cancer associated with the occupation of firefighting.

These four studies report an increased risk among firefighters, however, additional studies are required.

Table 6: Bladder Cancer

Study	Publication Year	Study Design	ICD Codes	Measure ¹	Observed /Cases	Expected Risk /Controls	Risk Estimate	95% CI	Notes
<i>Cancer Incidence Studies</i>									
Bates M, et al	2000	Cohort	188	SIR	5	4.4	1.14	(0.40, 2.70)	
Demers PA, et al	1994	Cohort	188	SIR	18	15.3	1.20	(0.70, 1.90)	Reference General Population
Demers PA, et al	1994	Cohort	188	IDR	18		1.70	(0.70, 4.30)	Reference Population Police
Sama S, et al	1990	Case-control	188	SMOR	26	--	1.59	(1.02, 2.50)	Reference Population State
Sama S, et al	1990	Case-control	188	SMOR	26	--	2.11	(1.07, 4.14)	Reference Population Police
<i>Cancer Mortality Studies</i>									
Burnett C, et al	1994	Surveillance	188	PMR	37	--	0.99	(0.70, 1.37)	All ages
Burnett C, et al	1994	Surveillance	188	PMR	9	--	1.01	(0.46, 1.93)	Age <65
Beaumont J, et al	1991	Cohort	not stated*	RR	5	--	0.57	(0.19, 1.35)	
Ma F, et al	1998	Cohort	not stated	MOR	48		1.2	(0.90, 1.60)	White males
Ma F, et al	1998	Cohort	not stated	MOR	1		1.3	--	Black males
Aronson KJ, et al	1994	Cohort	188	SMR	7	5.49	1.28	(0.51, 2.63)	
Baris D, et al	2001	Cohort	188	SMR	17	--	1.25	(0.77, 2.00)	
Bates M, et al	2000	Cohort	188	SMR	2	0.7	2.73	(0.30, 9.80)	
Demers PA, et al	1992	Cohort	188, 189.3-189.9*	SMR	2	--	0.23	(0.03, 0.83)	Reference General Population
Demers PA, et al	1992	Cohort	188, 189.3-189.9	IDR	2		0.16	(0.02, 1.24)	Reference Population Police
Guidotti TL	1993	Cohort	188	SMR	4	1.3	3.15	(0.86, 8.08)	
Vena & Fiedler	1987	Cohort	188	SMR	9	3.15	2.86	(1.30, 5.40)	

Shaded studies were eliminated as a result of quality assessment

* Bladder and other urinary

¹ SIR – Standardized Incidence Ratio, IDR—Incidence Density Ratio, SMOR – Standardized Morbidity Odds Ratio, PMR – Proportional Mortality Ratio, RR – Rate Ratio, MOR—Mortality Odds Ratio, SMR – Standardized Mortality Ratio

Table 7: Bladder Cancer—Analysis by Duration of Service

Study (year)	Ref Number	Study Design/ Country	ICD Codes	Duration of Service (Years)	Measure ¹	Number Observed/ Cases	Risk Estimate	95% Confidence Interval	Notes
Demers PA, et al (1994)	1135	Cohort	188	< 10	SIR	4	2.20	(0.60, 5.60)	
		USA		10-19		2	0.90	(0.10, 3.40)	
				20-29		9	1.00	(0.40, 1.80)	
				30+		3	1.60	(0.30, 4.80)	
Baris D, et al (2001)	7	Cohort	188	<=9	SMR	4	1.36	(0.51, 3.61)	
		USA		10-19		7	1.48	(0.70, 3.09)	
				20+		6	1.01	(0.45, 2.25)	
Vena & Fiedler (1987)	112	Cohort	188	1-9	SMR	1	5.00	--	
		USA		10-19		--	--	--	
				20-29		1	1.25	--	
				30-39		3	2.14	--	
				40+		4	5.71	--	

¹ SIR—Standardized Incidence Ratio, SMR—Standardized Mortality Ratio

Table 8: Brain and Nervous System Cancers

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected /Controls	Risk		Notes
	Year	Study Design					Estimate	95% CI	
<i>Cancer Incidence Studies</i>									
Brownson RC, et al	1990	Case-control	191-192	OR	--	--	2.00	(0.40, 9.60)	
Krishnan G, et al	2003	Case-control	9380-9481~	OR	6	1	5.88	(0.70, 49.01)	Age >20, longest held job
Krishnan G, et al	2003	Case-control	9380-9481~	OR	9	3	2.85	(0.77, 10.58)	Age >20, ever worked as a firefighter
Bates M, et al	2000	Cohort	191*	SIR	5	3.9	1.27	(0.40, 3.00)	
Demers PA, et al	1994	Cohort	191*	SIR	4	3.6	1.10	(0.30, 2.90)	Reference General Population
Demers PA, et al	1994	Cohort	191	IDR	4		1.40	(0.20, 11.0)	Reference Population Police
Tornling G, et al	1994	Cohort	191*	SIR	5	3.7	1.37	(0.44, 3.20)	
Sama S, et al	1990	Case-control	191-192~	SMOR	5	--	0.86	(0.34, 2.15)	Reference Population State
Sama S, et al	1990	Case-control	191-192~	SMOR	5	--	1.52	(0.39, 5.92)	Reference Population Police
<i>Cancer Mortality Studies</i>									
Burnett C, et al	1994	Surveillance	191,192	PMR	19	--	0.85	(0.52, 1.34)	Age <65
Burnett C, et al	1994	Surveillance	191,192	PMR	38	--	1.03	(0.73, 1.41)	All ages
Beaumont J, et al	1991	Cohort	not stated	RR	5	--	0.81	(0.26, 1.90)	
Grimes G, et al	1991	Surveillance	191,192	Risk Ratio	1.46%	0.39%	3.78	(1.22, 11.71)	
Ma F, et al	1998	Cohort	not stated	MOR	41		1	(0.80, 1.40)	White males
Ma F, et al	1998	Cohort	not stated	MOR	5		6.9	(3.0, 16.0)	Black males
Aronson KJ, et al	1994	Cohort	191-192	SMR	14	6.97	2.01	(1.10, 3.37)	
Baris D, et al	2001	Cohort	191-192	SMR	8	--	0.61	(0.31, 1.22)	
Bates M, et al	2000	Cohort	191*	SMR	2	3	0.68	(0.10, 2.40)	
Demers PA, et al	1992	Cohort	191,192	SMR	18	--	2.07	(1.23, 3.28)	Reference General Population
Demers PA, et al	1992	Cohort	191, 192	IDR	18		1.63	(0.70, 3.79)	Reference Population Police
Guidotti TL	1993	Cohort	191*	SMR	3	2.1	1.47	(0.30, 4.29)	
Musk AW, et al	1978	Cohort	193 (ICD7)	SMR	8	7.8	1.03	--	
Tornling G, et al	1994	Cohort	191*~	SMR	5	1.8	2.79	(0.91, 6.51)	
Vena & Fiedler	1987	Cohort	191,192	SMR	6	2.55	2.36	(0.86, 5.13)	

Shaded studies were eliminated as a result of quality assessment

¹ OR – Odds Ratio, SIR – Standardized Incidence Ratio, IDR—Incidence Density Ratio, SMOR – Standardized Morbidity Odds Ratio, PMR – Proportional Mortality Ratio, RR – Rate Ratio, MOR—Mortality Odds Ratio, SMR – Standardized Mortality Ratio

* brain only ~ all cases were gliomas

Table 9: Brain and Nervous System Cancers—Analysis by Duration of Service

Study (year)	Ref Number	Study Design/ Country	ICD Codes	Duration of Service (Years)	Measure ¹	Number Observed/ Cases	Risk Estimate	95% Confidence Interval	Notes
Demers PA, et al (1994)*	1135	Cohort USA	191	<10 10-19 20-29 30+	SIR	1 0 3 0	1.60 0 1.60 0	(0, 8.80) (0, 4.60) (0.30, 4.60) (0, 16.00)	
Tornling G, et al (1994)*	110	Cohort Sweden	191	<20 20-30 >30	SIR	0 1 4	0 0.78 3.25	(0, 3.22) (0.01, 4.35) (0.87, 8.33)	
Aronson KJ, et al (1994)	2	Cohort Canada	191-192	< 15 15 - 29 30+	SMR	5 3 5	2.62 1.06 2.29	(0.85, 6.11) (0.22, 3.10) (0.75, 5.35)	
Baris D, et al (2001)	7	Cohort USA	191-192	<=9 10-19 20+	SMR	2 2 4	0.47 0.44 0.94	(0.12, 1.89) (0.11, 1.75) (0.35, 2.49)	
Demers PA, et al (1992)**	25	Cohort USA	191,192,237.5,2 37.9,239.6,239.7	< 10 10-19 20-29 30+	SMR	5 8 6 3	2.57 3.53 1.24 2.04	(0.80, 6.00) (1.50, 7.00) (0.50, 2.70) (0.40, 5.90)	
Tornling G, et al (1994)*	110	Cohort Sweden	191	<20 20-30 >30	SMR	0 2 3	0 3.04 4.37	(0, 8.25) (0.37, 10.97) (0.90, 1.27)	
Vena & Fiedler (1987)	112	Cohort USA	191-192	1-9 10-19 20-29 30-39 40+	SMR	1 2 3 -- --	3.33 3.33 3.75 -- --	-- -- -- -- --	
¹ SIR—Standardized Incidence Ratio, SMR—Standardized Mortality Ratio									
* Brain only									
** Brain and nervous tumours									

Table 10: Colorectal Cancer

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected Risk		Notes
	Year	Study Design				/Controls	Estimate	
<i>Cancer Incidence Studies</i>								
Giles G, et al	1993	Cohort	153, 154	SIR	9	--	1.36	(0.62, 2.59)
Bates M, et al	2000	Cohort	153, 154 **	SIR	16	19.6	0.81	(0.50, 1.32)
Demers PA, et al	1994	Cohort	153, 154 **	SIR	35	31.8	1.10	(0.79, 1.53)
Tornling G, et al	1994	Cohort	153, 154 **	SIR	18	14.8	1.22	(0.77, 1.94)
<i>Cancer Mortality Studies</i>								
Guidotti TL	1993	Cohort	152-154 ~	SMR	14	8.7	1.61	(0.88, 2.71)
Eliopoulos E, et al	1984	Cohort	not stated*	SPMR	4	--	1.59	(0.43, 4.07)
Beaumont J, et al	1991	Cohort	not stated **	RR	37	33.14	1.12	(0.81, 1.54)
Aronson KJ, et al	1994	Cohort	153, 154 **	SMR	24	25.83	0.93	(0.62, 1.39)
Baris D, et al	2001	Cohort	153, 154 **	SMR	78	56.52	1.38	(1.11, 1.72)
Bates M, et al	2000	Cohort	153, 154 **	SMR	10	8.3	1.20	(0.65, 2.24)
Demers PA, et al	1992	Cohort	153, 154 **	SMR	32	36.65	0.87	(0.62, 1.23)
Tornling G, et al	1994	Cohort	153, 154 **	SMR	14	11	1.27	(0.75, 2.15)
Vena & Fiedler	1987	Cohort	153, 154 **	SMR	23	12.1	1.90	(1.26, 2.86)

¹ SIR – Standardized Incidence Ratio, SMR – Standardized Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio, RR – Rate Ratio

* "Intestinal" and "rectal" ~includes small intestine

** results reported for c olon and rectal cancer cer combined for this analysis as described in the methods

Table 11: Colon Cancer

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected Risk		95% CI	Notes
	Year	Study Design				/Controls	Estimate		
<i>Cancer Incidence Studies</i>									
Bates M, et al	2000	Cohort	153	SIR	7	11.8	0.60	(0.20, 1.20)	
Demers PA, et al	1994	Cohort	153	SIR	23	21	1.10	(0.70, 1.60)	Reference General Population
Demers PA, et al	1994	Cohort	153	IDR	23		1.30	(0.60, 3.00)	Reference Population Police
Tornling G, et al	1994	Cohort	153	SIR	8	8.9	0.90	(0.39, 1.77)	
Sama S, et al	1990	Case-control	153	SMOR	33	--	1.20	(0.80, 1.82)	Reference Population State
Sama S, et al	1990	Case-control	153	SMOR	33	--	1.04	(0.59, 1.82)	Reference Population Police
<i>Cancer Mortality Studies</i>									
Beaumont J, et al	1991	Cohort	not stated*	RR	24	--	0.99	(0.63, 1.47)	
Grimes G, et al	1991	Surveillance	153	Risk Ratio	2.44%	2.21%	0.91	(0.37, 2.20)	
Ma F, et al	1998	Cohort	not stated	MOR	149		1	(0.90, 1.20)	White males
Ma F, et al	1998	Cohort	not stated	MOR	9		2.1	(1.10, 4.0)	Black males
Aronson KJ, et al	1994	Cohort	153	SMR	11	18.24	0.60	(0.30, 1.08)	
Baris D, et al	2001	Cohort	153	SMR	64	--	1.51	(1.18, 1.93)	
Bates M, et al	2000	Cohort	153	SMR	6	5	1.19	(0.40, 2.60)	
Demers PA, et al	1992	Cohort	152, 153~	SMR	24	--	0.85	(0.54, 1.26)	Reference General Population
Demers PA, et al	1992	Cohort	152, 153	IDR	24		1.58	(0.73, 3.43)	Reference Population Police
Tornling G, et al	1994	Cohort	153	SMR	6	7.1	0.85	(0.31, 1.85)	
Vena & Fiedler	1987	Cohort	153	SMR	16	8.7	1.83	(1.05, 2.97)	

Shaded studies were eliminated as a result of quality assessment

¹ SIR – Standardized Incidence Ratio, IDR - Incidence Density Ratio, SMOR – Standardized Morbidity Odds Ratio, RR – Rate Ratio, MOR –Mortality Odds Ratio, SMR – Standardized Mortality Ratio,

* Intestine except rectum –includes small intestine

Table 12: Colon Cancer—Analysis by Duration of Service

Study (year)	Ref Number	Study Design/ Country	ICD Codes	Duration of Service (Years)	Measure ¹	Number Observed/ Cases	Risk Estimate	95% Confidence Interval	Notes
Bates M, et al (2000)	10	Cohort	153	<=10	SIR	1	0.41	(0, 2.30)	
		New Zealand		11 - 20	SIR	1	0.46	(0, 2.60)	
				> 20	SIR	5	1.37	(0.40, 3.20)	
Demers PA, et al (1994)	1135	Cohort	153	< 10	SIR	2	0.8	(0.10, 2.90)	
		USA		10-19		2	0.7	(0.10, 2.60)	
				20-29		15	1.1	(0.60, 1.90)	
				30+		4	1.5	(0.40, 3.90)	
Beaumont J, et al (1991)*	11	Cohort	not stated	3-9	RR	1	0.92	--	
		USA		10-19		4	1.67	--	
				20-29		7	0.64	--	
				30+		12	1.22	--	
Baris D, et al (2001)	7	Cohort	153	<=9	SMR	18	1.78	(1.12, 2.82)	
		USA		10-19		16	1.11	(0.68, 1.81)	
				20+		30	1.68	(1.17, 2.40)	
Demers PA, et al (1992)**	25	Cohort	152-153	< 10	SMR	4	1.40	(0.40, 3.60)	
		USA		10-19		2	0.54	(0.10, 2.00)	
				20-29		9	0.62	(0.30, 1.20)	
				30+		9	1.21	(0.60, 2.30)	
Vena & Fiedler (1987)	112	Cohort	153	1-9	SMR	--	--	--	
		USA		10-19		1	1.25	--	
				20-29		2	0.87	--	
				30-39		5	1.43	--	
				40+		8	4.71	--	

¹ SIR—Standardized Incidence Ratio, RR—Rate Ratio, SMR—Standardized Mortality Ratio.

* Cancer of the intestine

** Colon and small intestine

Table 13: Rectal Cancer

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected Risk			Notes
	Year	Study Design				/Controls	Estimate	95% CI	
<i>Cancer Incidence Studies</i>									
Bates M, et al	2000	Cohort	154	SIR	9	7.8	1.15	(0.50, 2.20)	
Demers PA, et al	1994	Cohort	154	SIR	12	11.8	1.00	(0.50, 1.80)	Reference General Population
Demers PA, et al	1994	Cohort	154	IDR	12		1.30	(0.50, 3.90)	Reference Population Police
Tornling G, et al	1994	Cohort	154	SIR	10	5.9	1.70	(0.81, 3.12)	
Sama S, et al	1990	Case-control	154	SMOR	22	--	1.35	(0.84, 2.19)	Reference Population State
Sama S, et al	1990	Case-control	154	SMOR	22	--	0.97	(0.50, 1.88)	Reference Population Police
<i>Cancer Mortality Studies</i>									
Burnett C, et al	1994	Surveillance	154	PMR	18	--	1.86	(1.10, 2.94)	Age <65
Burnett C, et al	1994	Surveillance	154	PMR	37	--	1.48	(1.05, 2.05)	All ages
Beaumont J, et al	1991	Cohort	not stated	RR	13	--	1.45	(0.77, 2.49)	
Ma F, et al	1998	Cohort	not stated	MOR	27		1.1	(0.80, 1.60)	White males
Aronson KJ, et al	1994	Cohort	154	SMR	13	7.59	1.71	(0.91, 2.93)	
Baris D, et al	2001	Cohort	154	SMR	14	--	0.99	(0.59, 1.68)	
Bates M, et al	2000	Cohort	154	SMR	4	3.3	1.21	(0.30, 3.10)	
Demers PA, et al	1992	Cohort	154	SMR	8	--	0.95	(0.41, 1.87)	Reference General Population
Demers PA, et al	1992	Cohort	154	IDR	8		0.09	(0.30, 2.66)	Reference Population Police
Tornling G, et al	1994	Cohort	154	SMR	8	3.9	2.07	(0.89, 4.08)	
Vena & Fiedler	1987	Cohort	154	SMR	7	3.4	2.08	(0.83, 4.28)	

Shaded studies were eliminated as a result of quality assessment

¹ SIR – Standardized Incidence Ratio, IDR—Incidence Density Ratio, SMOR – Standardized Morbidity Odds Ratio, PMR – Proportional Mortality Ratio, RR – Rate Ratio, MOR—Mortality Odds Ratio, SMR – Standardized Mortality Ratio.

Table 14: Rectal Cancer—Analysis by Duration of Service

Study (year)	Ref Number	Study Design/ Country	ICD Codes	Duration of Service (Years)	Measure ¹	Number Observed/ Cases	Risk Estimate	95% Confidence Interval	Notes
Bates M, et al (2000)	10	Cohort	154	<=10	SIR	2	1.22	(0.10, 4.40)	
		New Zealand		11 - 20		2	1.38	(0.20, 5.00)	
				> 20		4	1.61	(0.40, 4.10)	
Demers PA, et al (1994)	1135	Cohort	154	< 10	SIR	2	1.4	(0.20, 4.90)	
		USA		10-19		3	1.9	(0.40, 5.40)	
				20-29		5	0.7	(0.20, 1.60)	
				30+		2	1.6	(0.20, 5.60)	
Beaumont J, et al (1991)	11	Cohort	not stated	3-9	RR	0	0	--	
		USA		10-19		2	2.19	--	
				20-29		6	1.45	--	
				30+		5	1.42	--	
Aronson KJ, et al (1994)	2	Cohort	154	< 15	SMR	0	0	(0, 4.67)	
		Canada		15 - 29		5	2.35	(0.76, 5.48)	
				30+		8	1.74	(0.75, 3.43)	
Baris D, et al (2001)	7	Cohort	154	<=9	SMR	3	0.86	(0.28, 2.66)	
		USA		10-19		6	1.16	(0.52, 2.58)	
				20+		5	0.92	(0.38, 2.22)	

¹ SIR—Standardized Incidence Ratio, RR—Rate Ratio, SMR—Standardized Mortality Ratio.

Table 15: Kidney Cancer

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected Risk /Controls	Estimate	95% CI	Notes
	Year	Study Design							
<i>Cancer Incidence Studies</i>									
Delahunt B, et al	1995	Case-control	189	OR	--	--	3.51	(2.09, 5.92)	
Bates M, et al	2000	Cohort	189	SIR	2	3.5	0.57	(0.10, 2.10)	
Demers PA, et al	1994	Cohort	189	SIR	3	5.6	0.50	(0.10, 1.60)	Reference General Population
Demers PA, et al	1994	Cohort	189	IDR	3		0.40	(0.10, 2.10)	Reference Population Police
Tornling G, et al	1994	Cohort	189	SIR	2	5.6	0.36	(0.04, 1.29)	
<i>Cancer Mortality Studies</i>									
Burnett C, et al	1994	Surveillance	189.0-189.2*	PMR	24	--	1.41	(0.90, 2.10)	All ages
Burnett C, et al	1994	Surveillance	189.0-189.2*	PMR	53	--	1.44	(1.08, 1.89)	Age <65
Beaumont J, et al	1991	Cohort	not stated~	Rate Ratio	4	--	0.68	(0.19, 1.74)	
Ma F, et al #	1998	Cohort	not stated	MOR	49		1.3	(1.00, 1.70)	White males
Aronson KJ, et al	1994	Cohort	189	SMR	2	4.63	0.43	(0.05, 1.56)	
Baris D, et al	2001	Cohort	189	SMR	12	--	1.07	(0.61, 1.88)	
Demers PA, et al	1992	Cohort	189.0-189.2*	SMR	2	--	0.27	(0.03, 0.97)	
Guidotti TL	1993	Cohort	189	SMR	7	1.7	4.14	(1.66, 8.53)	
Tornling G, et al	1994	Cohort	189	SMR	4	3.7	1.10	(0.30, 2.81)	
Vena & Fiedler	1987	Cohort	189	SMR	3	2.3	1.30	(0.26, 3.80)	

Shaded studies were eliminated as a result of quality assessment

* Kidney and Ureter ~Kidney excluding other urinary #Kidney and renal pelvis

¹ OR – Odds Ratio, SIR – Standardized Incidence Ratio, IDR—Incidence Density Ratio, PMR – Proportional Mortality Ratio, SMR – Standardized Mortality Ratio.

Table 16: Kidney Cancer—Analysis by Duration of Service

Study (year)	Ref Number	Study Design/ Country	ICD Codes	Duration of Service (Years)	Measure ¹	Number Observed/ Cases	Risk Estimate	95% Confidence Interval	Notes
Baris D, et al (2001)	7	Cohort	189	<=9	SMR	2	0.72	(0.18, 2.87)	
				10-19		0	--	--	
				20+		10	2.20	(1.18, 4.08)	
Guidotti TL (1993)	42	Cohort	189	< 1	SMR	0	0.00	--	
				1-9		0	0.00	--	
				10-19		1	4.30	--	
				20-29		2	3.84	--	
				30-39		2	3.38	--	
				40+		2	36.12	--	

¹ SMR—Standardized Mortality Ratio

Table 17: Leukemia

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected Risk			Notes
	Year	Study Design				/Controls	Estimate	95% CI	
<i>Cancer Incidence Studies</i>									
Demers PA, et al	1994	Cohort	204-208	SIR	6	6.2	1.00	(0.40, 2.10)	Reference General Population
Demers PA, et al	1994	Cohort	204-208	IDR	6		0.80	(0.20, 3.50)	Reference Population Police
Giles G, et al	1993	Cohort	204-208	SIR	0	--	0.00	(0.00, 3.56)	
Morton & Marjanovic	1984	Surveillance	not stated	SIR	4.00	1.20	3.46	p<0.01	
Sama S, et al	1990	Case-control	H 980-994, excl. 984	SMOR	6	--	1.12	(0.48, 2.59)	Reference Population State
Sama S, et al	1990	Case-control	H 980-994, excl. 984	SMOR	6	--	2.67	(0.62, 11.54)	Reference Population Police
<i>Cancer Mortality Studies</i>									
Burnett C, et al	1994	Surveillance	204-208	PMR	33	--	1.71	(1.18, 2.40)	Age <65
Burnett C, et al	1994	Surveillance	204-208	PMR	61	--	1.19	(0.91, 1.53)	All ages
Feuer & Rosenman	1986	Cohort	204-207	PMR	4	2.15	1.86	--	Reference US population
Feuer & Rosenman	1986	Cohort	204-207	PMR	4	1.45	2.76	p<0.05	Reference Population Police
Beaumont J, et al	1991	Cohort	not stated	RR	6	--	0.61	(0.22, 1.33)	
Ma F, et al	1998	Cohort	not stated	MOR	60		1.1	(0.80, 1.40)	White males
Baris D, et al	2001	Cohort	204-207	SMR	15	--	0.83	(0.50, 1.37)	
Demers PA, et al	1992	Cohort	204-208	SMR	15	--	1.27	(0.71, 2.09)	Reference General Population
Demers PA, et al	1992	Cohort	204-208	IDR	15		0.80	(0.38, 1.70)	Reference Population Police

Shaded studies were eliminated as a result of quality assessment

¹ SIR – Standardized Incidence Ratio, IDR—Incidence Density Ratio, SMOR – Standardized Morbidity Odds Ratio, PMR – Proportional Mortality Ratio, RR – Rate Ratio, MOR—Mortality Odds Ratio, SMR – Standardized Mortality Ratio

Table 18: Leukemia—Analysis by Duration of Service

Study (year)	Ref Number	Study Design/ Country	ICD Codes	Duration of Service (Years)	Measure ¹	Number Observed/ Cases	Risk Estimate	95% Confidence Interval	Notes
Demers PA, et al (1994)	1135	Cohort USA	204-208	< 10	SIR	0	0	(0, 4.40)	
				10-19		2	1.90	(0.20, 6.80)	
				20-29		4	1.10	(0.30, 2.80)	
				30+		0	0	(0, 5.40)	
Baris D, et al (2001)	7	Cohort USA	204-207	<=9	SMR	5	0.94	(0.39, 2.25)	
				10-19		7	1.14	(0.54, 2.38)	
				20+		3	0.45	(0.15, 1.40)	
Demers PA, et al (1992)	25	Cohort USA	204-208	< 10	SMR	2	1.13	(0.10, 4.10)	
				10-19		2	1.04	(0.10, 3.70)	
				20-29		4	0.73	(0.20, 1.90)	
				30+		7	2.60	(1.00, 5.40)	

¹ SIR—Standardized Incidence Ratio, SMR—Standardized Mortality Ratio.

Table 19: Lung Cancer

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected Risk		95% CI	Notes
	Year	Study Design				/Controls	Estimate		
<i>Cancer Incidence Studies</i>									
Zahm S, et al	1989	Case-control	162	OR	--	--	1.60	(1.10, 2.30)	
Bates M, et al	2000	Cohort	162	SIR	17	15	1.14	(0.70, 1.80)	
Demers PA, et al	1994	Cohort	162	SIR	45	46.8	1.00	(0.70, 1.30)	Reference General Population
Demers PA, et al	1994	Cohort	162	IDR	45		1.10	(0.60, 1.90)	Reference Population Police
Firth HM, et al	1996	Surveillance	not stated	SIR	--	--	1.27	(0.46, 2.78)	
Giles G, et al	1993	Cohort	162	SIR	6	--	0.77	(0.28, 1.68)	
Tornling G, et al	1994	Cohort	162	SIR	16	17.9	0.89	(0.51, 1.45)	
Sama S, et al	1990	Case-control	162	SMOR	71	--	1.22	(0.87, 1.69)	Reference Population State
Sama S, et al	1990	Case-control	162	SMOR	71	--	1.30	(0.84, 2.03)	Reference Population Police
<i>Cancer Mortality Studies</i>									
Burnett C, et al	1994	Surveillance	162	PMR	236	--	0.98	(0.86, 1.12)	Age <65
Burnett C, et al	1994	Surveillance	162	PMR	562	--	1.02	(0.94, 1.11)	All ages
Beaumont J, et al	1991	Cohort	162	RR	60	--	0.84	(0.64, 1.08)	
Ma F, et al	1998	Cohort	not stated	MOR	633		1.1	(1.00, 1.20)	White males
Ma F, et al	1998	Cohort	not stated	MOR	15		0.8	(0.50, 1.30)	Black males
Aronson KJ, et al	1994	Cohort	162	SMR	54	57.07	0.95	(0.71, 1.24)	
Baris D, et al	2001	Cohort	162	SMR	162	--	1.13	(0.97, 1.32)	
Bates M, et al	2000	Cohort	162	SMR	10	11.7	0.86	(0.40, 1.60)	
Demers PA, et al	1992	Cohort	162	SMR	95	--	0.96	(0.77, 1.17)	Reference General Population
Demers PA, et al	1992	Cohort	162	IDR	95		0.95	(0.67, 1.33)	Reference Population Police
Guidotti TL	1993	Cohort	162	SMR	24	16.9	1.42	(0.91, 2.11)	
Hansen ES	1990	Cohort	162	SMR	9	--	1.63	(0.75, 3.10)	
Tornling G, et al	1994	Cohort	162	SMR	18	20.1	0.90	(0.53, 1.42)	

Shaded studies were eliminated as a result of quality assessment

¹ OR – Odds Ratio, SIR – Standardized Incidence Ratio, IDR - Incidence Density Ratio, SMOR – Standardized Morbidity Odds Ratio, PMR – Proportional Mortality Ratio, RR – Rate Ratio, MOR—Mortality Odds Ratio, SMR – Standardized Mortality Ratio.

Table 20: Lung Cancer—Analysis by Duration of Service

Study (year)	Ref Number	Study Design/ Country	ICD Codes	Duration of Service (Years)	Measure ¹	Number Observed/ Cases	Risk Estimate	95% Confidence Interval	Notes
Bates M, et al (2000)	10	Cohort	162	<=10	SIR	3	0.93	(0.20, 2.70)	
		New Zealand		11 - 20		4	1.45	(0.40, 3.70)	
				> 20		8	1.52	(0.70, 3.00)	
Demers PA, et al (1994)	1135	Cohort	162	< 10		8	1.40	(0.60, 2.70)	
		USA		10-19	SIR	9	1.40	(0.70, 2.70)	
				20-29		26	0.90	(0.60, 1.30)	
				30+		2	0.40	(0.10, 1.50)	
Aronson KJ, et al (1994)	2	Cohort	162	< 15	SMR	8	1.30	(0.56, 2.57)	
		Canada		15 - 29		16	0.85	(0.49, 1.38)	
				30+		27	0.85	(0.56, 1.24)	
Baumont J, et al (1991)	11	Cohort	not stated *	3-9	RR	3	0.82	--	
		USA		10-19		5	0.63	--	
				20-29		27	0.79	--	
				30+		25	0.98	--	
Baris D, et al (2001)	7	Cohort	162	<=9	SMR	50	1.52	(1.16, 2.01)	
		USA		10-19		56	1.20	(0.92, 1.56)	
				20+		56	0.89	(0.68, 1.15)	
Guidotti TL (1993)	42	Cohort	162	< 1	SMR	2	2.83	--	
		Canada		1-9		4	1.97	--	
				10-19		3	1.49	--	
				20-29		6	1.31	--	
				30-39		7	1.07	--	
				40+		2	2.02	--	

¹ SIR—Standardized Incidence Ratio, SMR—Standardized Mortality Ratio, RR—Rate Ratio.

* Lung and respiratory

Table 21: Multiple Myeloma

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected Risk /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<i>Cancer Incidence Studies</i>									
Demers PA, et al	1993	Case-control	not stated	OR	5	5	1.90	(0.50, 9.40)	
Demers PA, et al	1994	Cohort	203	SIR	2	2.8	0.70	(0.10, 2.60)	
<i>Cancer Mortality Studies</i>									
Burnett C, et al	1994	Surveillance	203	PMR	11	--	1.36	(0.68, 2.43)	Age <65
Burnett C, et al	1994	Surveillance	203	PMR	34	--	1.48	(1.02, 2.07)	All ages
Ma F, et al	1998	Cohort	not stated	MOR	28		1.1	(0.80, 1.60)	White males
Ma F, et al	1998	Cohort	not stated	MOR	1		0.8	--	Black males
Baris D, et al	2001	Cohort	203	SMR	10	--	1.68	(0.90, 3.11)	

Shaded studies were eliminated as a result of quality assessment

¹ OR – Odds Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, MOR—Mortality Odds Ratio, SMR – Standardized Mortality Ratio.

Table 22: Multiple Myeloma—Analysis by Duration of Service

Study (year)	Ref Number	Study Design/ Country	ICD Codes	Duration of Service (Years)	Measure ¹	Number Observed/ Cases	Risk Estimate	95% Confidence Interval	Notes
Demers PA, et al (1993)	1146	Case-control	not stated	<10	OR	1	0.90	(0, 22.30)	
		USA		10+		4	2.90	(0.4, 21.6)	
Baris D, et al (2001)	7	Cohort	203	<=9	SMR	1	0.73	(0.10, 5.17)	
		USA		10-19		3	1.50	(0.48, 4.66)	
				20+		6	2.31	(1.04, 5.16)	

¹ OR—Odds Ratio, SMR—Standardized Mortality Ratio.

Table 23: Non-Hodgkin Lymphoma

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected Risk			Notes
	Year	Study Design				/Controls	Estimate	95% CI	
<i>Cancer Incidence Studies</i>									
Demers PA, et al	1994	Cohort	200-202	SIR	7	7.7	0.90	(0.40, 1.90)	Reference General Population
Demers PA, et al	1994	Cohort	200-202	IDR	7		1.80	(0.40, 13.0)	Reference Population Police
Giles G, et al	1993	Cohort	200, 202	SIR	4	--	1.85	(0.50, 4.74)	
Sama S, et al	1990	Case-control	H 959-964, 967-970, 972, 975-976	SMOR	14	--	1.59	(0.89, 2.84)	Reference Population State
Sama S, et al	1990	Case-control	H 959-964, 967-970, 972, 975-976	SMOR	14	--	3.27	(1.19, 8.98)	Reference Population Police
<i>Cancer Mortality Studies</i>									
Figgs LW, et al	1995	Case-control	200, 202 excl. 202.3 and 202.6	OR	12	--	5.60	(2.50, 12.30)	
Burnett C, et al	1994	Surveillance	200, 202	PMR	35	--	1.61	(1.12, 2.24)	Age <65
Burnett C, et al	1994	Surveillance	200, 202	PMR	66	--	1.32	(1.02, 1.67)	All ages
Ma F, et al	1998	Cohort	not stated	MOR	76		1.4	(1.10, 1.70)	White males
Ma F, et al	1998	Cohort	not stated	MOR	1		0.8	--	Black males
Baris D, et al	2001	Cohort	200, 202	SMR	20	--	1.41	(0.91, 2.19)	

Shaded studies were eliminated as a result of quality assessment

¹ SIR – Standardized Incidence Ratio, IDR—Incidence Density Ratio, SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, PMR – Proportional Mortality Ratio, MOR—Mortality Odds Ratio, SMR – Standardized Mortality Ratio.

Table 24: Non-Hodgkin Lymphoma—Analysis by Duration of Service

Study (year)	Ref Number	Study Design/ Country	ICD Codes	Duration of Service (Years)	Measure ¹	Number Observed/ Cases	Risk Estimate	95% Confidence Interval	Notes
Demers PA, et al (1994)	1135	Cohort USA	200-202	< 10	SIR	1	0.90	(0, 4.90)	
				10-19		1	0.60	(0, 3.50)	
				20-29		5	1.20	(0.40, 2.70)	
				30+		0	0	(0, 5.80)	
Baris D, et al (2001)	7	Cohort USA	200,202	<=9	SMR	6	1.47	(0.66, 3.26)	
				10-19		5	1.03	(0.43, 2.47)	
				20+		9	1.72	(0.9, 3.31)	

¹ SMR—Standardized Mortality Ratio, SIR—Standardized Incidence Ratio.

Table 25: Testicular Cancer

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected Risk /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<i>Cancer Incidence Studies</i>									
Stang A, et al	2003	Case-control	not stated	OR	4	3	4.30	(0.70, 30.5)	
Bates M, et al	2000	Cohort	186	SIR	11	7.1	1.55	(0.80, 2.80)	
Giles G, et al	1993	Cohort	186	SIR	2	--	1.15	(0.13, 4.17)	
<i>Cancer Mortality Studies</i>									
Ma F, et al	1998	Cohort	not stated	MOR	1		0.6	--	White males
Aronson KJ, et al	1994	Cohort	186	SMR	3	1.19	2.52	(0.52, 7.37)	

Shaded studies were eliminated as a result of quality assessment

¹ OR – Odds Ratio, SIR – Standardized Incidence Ratio, MOR—Mortality Odds Ratio, SMR – Standardized Mortality Ratio.

Table 26: Testicular Cancer—Analysis by Duration of Service

Study (year)	Ref Number	Study Design/ Country	ICD Codes	Duration of Service (Years)	Measure ¹	Number Observed/ Cases	Risk Estimate	95% Confidence Interval	Notes
Stang A, et al (2003)	1138	Case-control Germany	not stated	10+	OR	2	3.00	(0.20, 45.50)	
Bates M, et al (2000)	10	Cohort New Zealand	186	<=10 11 - 20 > 20	SIR	3 4 2	1.55 3.51 4.14	(0.30, 4.50) (1.00, 9.00) (0.50, 14.90)	
Aronson KJ, et al (1994)	2	Cohort Canada	186	< 15 15 - 29 30+	SMR	3 0 0	3.66 0 0	(0.75, 10.69) (0, 14.19) (0, 36.89)	

¹ OR—Odds Ratio, SIR—Standardized Incidence Ratio, SMR—Standardized Mortality Ratio.

5.0 Discussion

Our review found limited evidence of an increased risk for brain cancer and colorectal cancers in firefighters. We found no evidence of an increased risk for lung or kidney cancer. For the remaining cancer sites considered, there are insufficient data from good quality studies to determine whether or not there is an increased risk associated with the occupation of firefighting.

The following table summarizes our findings by cancer site. The number of incidence and mortality studies available for analysis for each cancer site are indicated. For cancer sites with poor prognosis, it is highly likely that incidence and mortality are measuring the same outcome. For cancer sites with good or fair survival, studies of mortality may also be reflecting factors related to survival.

Pooled risk estimates for cancers of the brain and nervous system were 1.45 (95%CI: 0.84, 2.49) for incidence and 1.41 (95%CI: 0.97, 2.06) for mortality. Occupational exposure to vinyl chloride, acrylonitrile, and formaldehyde have been associated with an increased risk of brain cancer. Studies of firefighter exposure have recorded levels of formaldehyde which exceed recommended ceiling or short-term exposure levels at some structural fires.

The pooled risk estimates for colorectal cancer incidence and mortality were 1.08 (95%CI: 0.86, 1.35) and 1.24 (95%CI: 1.04, 1.47) respectively. The pooled risk estimates for incidence of colon and rectum separately were 0.97 (95%CI: 0.69, 1.36) and 1.25 (95%CI: 0.84, 1.85). In comparison to police officers, firefighters had an increased risk of incidence of both colon and rectal cancers. Although colorectal cancers are not typically associated with occupational exposures asbestos and vinyl chloride have been associated with increased risk. Asbestos fibers have been found in colon tissue of asbestos workers (Ehrlich et al., 1991). The mechanism for an effect of asbestos on colorectal cancer is not clear. Markowitz and colleagues (1991) report typical asbestos-induced pleural thickening among firefighters without prior asbestos exposure. One study of cancer among firefighters reported four cases of pleural cancer among U.S. firefighters (Ma et al., 1998). Other studies did not specify whether or not cases of mesothelioma were observed.

An exploratory case-control study based in Montreal (Goldberg et al., 2001) reports that adjusting for potential confounders did not appreciably change the risk estimate for colon cancer among firefighters as compared to population controls. Adjusting for confounders increased the risk estimate from an age-adjusted odds ratio of 1.3 to a fully-adjusted odds ratio of 1.5 (95%CI: 1.0, 2.1). Similarly, a study of associations between occupational exposures and colorectal cancers found that adjusting for confounders (diet, BMI, and physical activity) had little or no influence on risk estimates for the association between cancers of the colon or rectum and exposure to soot, asbestos or combustion gases from coal/coke/wood (Gerhardsson de Verdier et al., 1992).

Table 27: Summary of Findings by Cancer Site

Cancer Site	Number of Good Quality Studies		Survival by cancer site ¹	Findings
	Incidence	Mortality		
bladder	2	7	Good	Insufficient data to determine whether or not there is an increased risk associated with the occupation of firefighting
brain and CNS	4	8	Poor	Limited evidence of increased risk associated with occupation of firefighting
colorectal	4	9	Fair	Limited evidence of increased risk associated with occupation of firefighting
kidney	4	7	Fair	No evidence of increased risk associated with occupation of firefighting
leukemia	1	3	Fair	Insufficient data to determine whether or not there is an increased risk associated with the occupation of firefighting
lung	4	8	Poor	No evidence of increased risk associated with occupation of firefighting
multiple myeloma	2	1	Poor	Insufficient data to determine whether or not there is an increased risk associated with the occupation of firefighting
non-Hodgkin lymphoma	2	1	Good	Insufficient data to determine whether or not there is an increased risk associated with the occupation of firefighting
testicular	3	1	Good	Insufficient data to determine whether or not there is an increased risk associated with the occupation of firefighting

¹ Poor – 5 year survival less than 30%; Fair – 5 year survival 30-69%; Good – 5 year survival 70-84%

The majority of studies in this review used occupation as a surrogate for exposures experienced by individual firefighters. Grouping firefighters by job title rather than actual exposure or opportunity for exposure may result in an underestimate of the true effect. A few studies were able to define exposure in terms of years of active duty in positions involving fire combat (Demers et al., 1992; Guidotti, 1993) or number of runs (Baris et al., 2001). Effect of a dose response relationship, if it exists, would be obscured if exposures leading to increased risk are not present at all fires. The cancer risk for individuals with higher exposure would be diluted by inclusion of individuals with less chance of exposure.

Many of the studies covered broad geographic areas or spanned many decades. These studies would be subject to issues related to: changes in exposure over time, as agents would be introduced and regulated over different time periods; changes in cancer diagnosis and detection; and changes in protective equipment. Exposures experienced by firefighters may also vary by the area or station at which they serve. Firefighters working in residential areas may experience

different exposures than firefighters responding to fires in commercial areas or servicing major highways.

The healthy worker effect refers to bias introduced when the health of a working cohort is compared to that of the general population. Individuals must generally be healthy to secure employment and to remain employed. The healthy worker effect has been observed for firefighters. A number of studies have reported lower overall mortality for firefighters as compared to the general population and this is true of a number of studies reviewed here. This is not surprising as firefighters are required to meet a minimum level of physical fitness. The healthy worker effect, however, would have less impact on deaths due to cancer than on deaths due to other conditions. Studies using proportional mortality ratios, which are more sensitive to this type of bias, were excluded from the meta-analysis.

The survivor effect is a related phenomenon which can lead to an observation of lesser mortality with prolonged follow up for an occupationally-related disease. This may be due in part to attrition of workers who are more susceptible. With increasing years of employment there is a decline in workers with associated risk factors. The phenomenon has been observed among asbestos workers where smoking rates declined with longer duration of service.

As with other systematic literature reviews, publication bias is likely to be a factor. A number of studies examining occupational groups did not report findings for firefighters specifically and a number reported only findings which were statistically significant. Given the number of analyses, multiple testing may lead to a significant finding due to chance. Consistency of results across studies was also considered in reaching conclusions.

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Glossary of Terms

Carcinogen – Any substance that can cause cancer.

Case-control study – An epidemiologic study design that compares two groups of people: those with the disease or condition under study (cases) and a similar group of people who do not have the disease or condition (controls). Researchers study the medical, lifestyle and occupational histories of the people in each group to learn what factors may be associated with the disease or condition. For example, one group may have been exposed to a particular substance that the other was not.

CINAHL - An electronic database which regularly indexes about 1600 journals, providing coverage of literature related to nursing and allied health.

Cohort – A group of individuals, with something in common, who are followed over time.

Cohort study – An epidemiologic study design which classifies individuals as having been exposed or not exposed and then follows them over time to determine if the rate of developing a disease or condition is different in the exposed and unexposed groups. For example, a cohort of smokers and non-smokers may be followed over time to determine if one group is more likely to develop lung cancer.

Confounder - A variable that is associated with both the exposure and the outcome under investigation, but is not an intermediate variable. Unless it is possible to adjust for confounding variables, their effects cannot be distinguished from those of other factors being studied.

Dose–response relationship –A relationship in which a change in amount, intensity, or duration of exposure is associated with a change in risk of a specified outcome.

EMBASE - An electronic biomedical and pharmaceutical database indexing over 3,500 international journals in the fields of drug research, pharmacology, pharmaceuticals, toxicology, clinical and experimental human medicine, health policy and management, public health, occupational health, environmental health, drug dependence and abuse, psychiatry, forensic medicine, and biomedical engineering/instrumentation.

Exploded - A search function available in MEDLINE and other indices of published literature to retrieve a term and all of its narrower terms within the MeSH (see ‘Medical Subject Heading’) hierarchy.

HealthStar - An electronic database which contains citations to published literature on health services, technology, administration, and research. It focuses on both the clinical and non-clinical aspects of health care delivery, including health policy, laws and regulation, evaluation of patient outcomes, and effectiveness of programs.

Healthy worker effect – A phenomenon observed initially in studies of occupational diseases: Workers usually exhibit lower overall death rates than the general population, because the severely ill and chronically disabled are ordinarily excluded from employment.

Incidence – The number of new cases of a disease occurring in a defined population within a specified period of time.

Latent period – A delay between exposure to a disease-causing agent and the appearance of signs or symptoms of the disease.

Medical Subject Headings (MeSH) - Terms used by the United States National Library of Medicine to index articles in Index Medicus and MEDLINE. Designed to reduce problems that arise from, for example, differences in British and American spelling. The MeSH system has a tree structure in which broad subject terms branch into a series of progressively narrower subject terms.

MEDLINE - The United States National Library of Medicine's electronic database of bibliographic citations and author abstracts from more than 4,600 biomedical journals published in over 70 countries. Citations start from the mid-1960s and provide information pertaining to medicine, nursing, dentistry, veterinary medicine, allied health, and pre-clinical sciences.

Meta-analysis – The process of using statistical methods to combine the results of different studies. The aim is to integrate the findings and identify the overall trend of results. Meta-analysis has both a qualitative component (including critical appraisal of studies) and a quantitative component (including statistically combining numerical data).

Observational study – Epidemiologic study that does not involve any intervention, experimental or otherwise. Examples include case-control and cohort studies.

Odds ratio (OR) – A ratio of the odds that a person with disease was exposed relative to the odds that a person without disease was exposed.

Pooled estimate – see ‘summary risk estimate’.

Proportional (or proportionate) mortality ratio (PMR) – The proportion of observed deaths from a specified condition in a population, divided by the proportion of deaths expected from this condition in the reference population, expressed either on an age-specific basis or after age adjustment.

Risk factor – An exposure or characteristic that is associated with an increased occurrence of a disease or condition in an individual.

Risk ratio - A comparison of the risk of some health-related event, such as disease or death in two groups.

Standardized incidence ratio (SIR) – The ratio of number of incident cases diagnosed in the study population to the number of incident cases that would be expected based on rates in the general or comparison population. The ratio is often expressed as a percentage.

Standardized mortality (or morbidity) ratio (SMR) – The ratio of the number of deaths observed in the study population to the number that would be expected if the study population had the same rates as the general or comparison population. The ratio is often expressed as a percentage.

Statistical significance – A difference is said to be statistically significant if it is greater than what might be expected to happen by chance alone.

Summary risk estimate – An estimate of risk obtained by statistically combining data from different studies.

Systematic review – A summary of the medical literature that uses explicit methods to perform a comprehensive literature search and critical appraisal of individual studies on a specific topic. Statistical methods (meta-analysis) may or may not be used to analyse and summarise the results of the included studies.

Web of Science - An online index that provides access to five databases containing information gathered from scholarly journals in all areas of research: Science Citation Index Expanded™ , Social Sciences Citation Index® , Arts & Humanities Citation Index® , Index Chemicus® , Current Chemical Reactions® .

Some of the above glossary definitions were taken or adapted from:

A Dictionary of Epidemiology Fourth edition by John M. Last Associate editors: Robert A Spasoff, Susan S. Harris, Michel G. Thuriaux. Oxford University Press: 2001
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<http://www.cochrane.org/resources/glossary.htm>

National Cancer Institute, U. S. National Institutes of Health. Dictionary of Cancer Terms.
<http://www.cancer.gov/dictionary/>

Wikimedia Foundation Inc. Wikipedia: The free encyclopedia.
http://en.wikipedia.org/wiki/Main_Page

Appendix A Overview of Included Studies

The Occupation of Firefighting and Cancer Risk: Assessment of the Literature
Chaudhry R, Marrett L, Kreiger N, Sullivan T

Table 1: Summary of Cohort Studies

Authors	Aronson KJ, et al.	Baris D, et al.	Bates M, et al.	Beaumont J, et al.	Demers PA, et al.	Demers PA, et al.
Publication year	1994	2001	2000	1991	1994	1992
Geographic Region	Canada (Toronto)	USA (Philadelphia)	New Zealand (all)	USA (San Francisco)	USA (Seattle & Tacoma, WA)	USA (Seattle, Tacoma, Portland)
Outcome	Mortality	Mortality	Incidence & Mortality	Mortality	Incidence	Mortality
Study Years (enrolment)	1950-89	1925-86	1977-95	1940-70	1944-79	1944-1979
Years of Follow-up	1950-89	1986	Incidence: 1977-96 Mortality: 1977-95	1940-82	1974-89	1945-1989
Study Population	Toronto area firefighters	Philadelphia Fire Department firefighters	Full-time paid firefighters (men and women)	White, male firefighters of the San Francisco Fire Department	Male firefighter residents of Washington State	Male firefighters
Occupation/Exposure Data Source	Fire Department Records	Philadelphia Fire Department Employee Service Records	United Fire Brigades Association of New Zealand	SFFD personnel records	Fire department records	
Reference Population	Ontario male population	US White male population	New Zealand population	US death rates for white males	1) Male graduates of Seattle Police Academy (1944-78) 2) Tacoma policemen employed for at least one year between 1944-79 3) Local male population	1) US white males, 2) Police officers
Outcome Data Source	Death certificates	Vital statistics, National Death Index, pension, death certificates and other records	New Zealand Health Information Service	Death certificates, personnel records, municipal employee retirement records, California Automated Mortality Linkage System	Cancer Surveillance System of Fred Hutchinson Cancer Research Center	Death certificates
Total Subjects Included for Analysis	Males = 5373 Females: Excluded	Males = 7789 Females: Excluded	Males = 4221 Females: Excluded	Males = 3066 Females: Excluded	Males = 2447 Females: Excluded	Males = 4546 Females: Excluded
Total Subjects Excluded	Males: 476	722	Males: 53	Not stated	120	Not stated
Duration of Service	Min = 0.5 year Max = 55 years Mean = 20 years	Min = <1.0 years Max = 48 years Mean = 18 years	Min = 1 year Max = 41+ years Mean = 15.9 years	Min = 3 years Max=30+ years Mean = Not stated	Min=1 year Max=30+ years Mean = Not stated	Min=1 years Max=30+ years Mean = Not stated
Age at Hire	Min = 16 Max = 62 Mean = 25	Min = 16 Max = 63 Mean = 27	Not stated	Not stated	Not stated	Not stated
Duration of Follow-up	Min = 0.4 Max = 40 Mean = 21	Min = <1.0 Max = 62 Mean = 26	Min=<5 Max=19 Mean (men)=13.9	Not stated	Not stated	Not stated
Notes	10.4% of initially eligible total were excluded		3.2% of initially eligible total were excluded		4.7% of initially eligible total were excluded	

The Occupation of Firefighting and Cancer Risk: Assessment of the Literature
 Chaudhry R, Marrett L, Kreiger N, Sullivan T

Table 1: Summary of Cohort Studies (continued)

Authors	Deschamps S, et al. *	Eliopoulos E, et al.	Feuer & Rosenman *	Giles G, et al.	Guidotti TL	Hansen ES
Publication year	1995	1984	1986	1993	1993	1990
Geographic Region	France (Paris)	Australia (Western Australia)	USA (New Jersey)	Australia (Melbourne)	Canada (Edmonton & Calgary)	Denmark
Outcome	Mortality	Mortality	Mortality	Incidence	Mortality	Mortality
Study Years (enrolment)	1977	1939-78	1974-80	1917-89	1927-87	1970
Years of Follow-up	1977-91	1939-78	1974-80	1980-89	1927-87	1970-80
Study Population	Male professional Firefighters (minimum 5 years service)	Male, permanent, full-time firefighters employed by the Western Australia Fire Brigade	Paid white male firefighters	Male firefighters employed by the Metropolitan Fire Brigade in Melbourne, Australia	Urban firefighters in Calgary and Edmonton, Alberta	Employed males between ages of 15 – 69 reporting occupation of “firefighter” or “fireman” on national census
Occupation/Exposure Data Source	Brigade des sapeurs-pompiers de Paris staff records	Western Australia Fire Brigade	Police and Firemen Retirement System	Metropolitan Fire Brigade archives, annual reports, and payroll and union records	Personnel files of Calgary and Edmonton Fire Departments	National Census of Denmark from 1970
Reference Population	French male population	Western Australia males	1) US population 2) New Jersey white male population 3) New Jersey white male police	Population of Victoria	Males from province of Alberta	Male civil servants and salaried employees
Outcome Data Source	Pension records, Inst. National de la Sante/ Recherche Medicale	Death certificates	New Jersey vital statistics, death certificates	Victoria Cancer Registry	Employment, provincial health records, death certificates, Alberta/ Canadian vital statistics	National Register of Persons and National Register of Deaths
Total Subjects Included for Analysis	Males = 830 Females: Excluded	Males = 990 Females: Excluded	Males = 263 Females: Excluded	Males = 2865 Females: Excluded	Total = 3193	Males = 886
Total Lost to Follow-up					135	
Total Subjects Excluded	Not stated	17	Not stated	Not stated	Not stated	Not stated
Duration of Service	Min = 5 years Max = Not stated Mean = 18	Min = < 1 year Max = 30+ years Mean = Not stated	Min = 10 years Max = 25+ years Mean = Not stated	Min = <15 years Max = >30 years Mean = Not stated	Min = <1 year Max = 40+ years Mean = Not stated	Not stated
Age at Hire	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated
Duration of Follow-up	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated
Notes						

* Studies not included in the quantitative analysis

The Occupation of Firefighting and Cancer Risk: Assessment of the Literature
 Chaudhry R, Marrett L, Kreiger N, Sullivan T

Table 1: Summary of Cohort Studies (continued)

Authors	Lewis SS, et al. *	Mastromatteo E *	Musk AW, et al.	Tornling G, et al.	Vena & Fiedler
Publication year	1982	1959	1978	1994	1987
Geographic Region	USA (Los Angeles)	Canada (Toronto)	USA (Boston)	Sweden (Stockholm)	USA (Buffalo)
Outcome	Mortality	Mortality	Mortality	Incidence & Mortality	Mortality
Study Years (enrolment)	1940-80	1921-53	1915-75	1931-1983	1950-1979
Years of Follow-up	1940-80	1921-1953	1915-75	Incidence: 1958-1986, Mortality: 1951-1986	1950-1979
Study Population	Firefighters in Los Angeles area	Active and pensioned firemen between 1921-1953	Male firefighters in Boston, Massachusetts	Stockholm male firefighters with minimum 1 year experience	White males who worked at least one year as a firefighter in Buffalo, NY
Occupation/Exposure Data Source	Not stated	Benefit Fund Register		Annual enrollment records from fire stations	
Reference Population	US white males	Ontario men and city men	1) White males in US 2) All males in Massachusetts 3) White males in Massachusetts	Males living in Stockholm County	US general population
Outcome Data Source	Death certificates	Death certificates, Registrar General of Ontario	Death certificates	Incidence: Cancer registry Mortality: Death certificates	Death certificates
Total Subjects Included for Analysis	Males = 6722 Females: Not stated	Total = 1039	Males = 5655 Females: Excluded	Incidence: Males = 1091 Mortality: Males = 1116 Females: Excluded for both	Males = 1867
Total Lost to Follow-up		20%	246 lost to follow up 194 could not locate death certificates		
Total Subjects Excluded	80			37	
Duration of Service	Not stated	Not stated	Min = 3 years Max = Not stated Mean = Not stated	Min = 1 year Max = 30+ years	Min = 1 year Max = 40+ years
Age at Hire	Not stated	Not stated	Min = < 20 Max = > 40 Mean = Not stated	Not stated	Min = <24 Max = 30+ Mean = Not stated
Duration of Follow-up	Not stated	Not stated	Not stated	Not stated	Not stated
Notes	<ul style="list-style-type: none"> 1.2% (n=80) of initially eligible total were excluded 			<ul style="list-style-type: none"> 3.2% of initially eligible total were excluded 	

* Studies not included in the quantitative analysis

The Occupation of Firefighting and Cancer Risk: Assessment of the Literature
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Table 2: Summary of Case-Control Studies

Authors	Brownson RC, et al. *	Delahunt B, et al.	Demers PA, et al.	Figgs LW, et al. *	Krishnan G, et al.	Krstev S, et al.
Publication year	1990	1995	1993	1995	2003	1998
Geographic Region	USA (Missouri)	New Zealand	USA (4 regions)	USA (24 states)	USA (San Francisco)	USA (Atlanta, Detroit, New Jersey)
Outcome	Incidence – brain cancer	Incidence – renal cell cancer	Incidence - Cancer	Mortality – Non-Hodgkins Lymphoma	Incidence – brain cancer	Incidence – prostate cancer
Study Years (enrolment)	1984-88	1978-86	1977-81	1984-89	1991-94, 1997-99	1986-89
Study Population	White males with histologically confirmed cancer	Male renal cell cancer patients over the age of 20 years	Cancer patients under the age of 80 years	Deceased individuals, Non-Hodgkins Lymphoma	Brain cancer patients aged 20 years and older	Prostate cancer patients, men aged 40 – 79 years
Occupation/ Exposure Data Source	Hospital record (cancer registry)	Cancer registry- not otherwise stated	Interview, work history	Death certificates	Interview (patient or proxy), work history	Interviews, work history
Reference Population	Male cancer patients with other type of cancer (excludes ICD 199, 195)	Cancer patients (sites other than urinary tract) over the age of 20 years	General population	Deceased individuals, other causes	General population aged 20 years and older	General population, men aged 40 – 79 years
Outcome Data Source	Missouri cancer registry	Cancer registry	Tumor registries (SEER)	Death certificates	Northern California Cancer Center Rapid Case Ascertainment Program	Cancer registries – population based
Case Selection Method	All cases (brain and CNS)	All cases	All cases	All cases	All reported cases	Random within site, age and race
Control Selection Method	Random	Random	Random	Not stated	Random digit dialing	< 65 years: Random digit dialing; > 65 years: Random selection through Health Care Finances Admin. stratified by age
Control Matching Criteria	Age	Not stated	Age, Gender	Age, Race, Gender, Geography, Region	Age (5 years), Gender, Ethnicity	Age, Geographic region, Race
Number of Cases	Males Police and Fire Protection Services = 12 Females: Excluded	Male Firefighters = Not stated Females: Excluded	Males Prevention Services = 5	Males = 12 Females = 0	Males = 9 Females = 0	Male Firefighters = 10 Females: Excluded
Duration of Service					Min = 1 year	Min = 6 months
Age at Hire						
Notes	<ul style="list-style-type: none"> ▪ 34% of initially eligible total were Excluded ▪ Firefighters included as part of Police, Firefighters and Protection Service Workers 	<ul style="list-style-type: none"> ▪ captured smoking history 	<ul style="list-style-type: none"> ▪ 11% of initially eligible total were Excluded ▪ Firefighters included as part of Preventive Occupations 		<ul style="list-style-type: none"> ▪ Approximately 22% (n=250) of initially eligible total were Excluded 	<ul style="list-style-type: none"> ▪ 0.6% (n=6) of initially eligible total were Excluded

* Studies not included in the quantitative analysis

The Occupation of Firefighting and Cancer Risk: Assessment of the Literature
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Table 2: Summary of Case-Control Studies (continued)

Authors	Krestev S, et al. *	Muscat & Wynder *	Sama S, et al. *	Stang A, et al.	Zahm S, et al. *
Publication year	1998	1995	1990	2003	1989
Geographic Region	USA (24 States)	Not Stated	USA (Massachusetts)	Germany (5 regions)	USA (Missouri)
Outcome	Mortality – Prostate cancer	Incidence – laryngeal cancer	Incidence – nine cancer sites	Incidence – testicular cancer	Incidence – lung cancer
Study Years (enrolment)	1984-93	1985-92	1982-1986	1995-97	1980-85
Study Population	Males having cancer listed as the underlying cause of death on death certificate	White, male cancer patients admitted to hospital	White male cancer patients over the age of 18 years	Cancer patients aged 15 – 69 years	White male cancer patients
Reference Population	Male dying from causes other than cancer	White males admitted to hospital	White male cancer patients: 1 – police 2 – other sites	German population within 5 regions, aged 15 – 69 years	All white male cancer patients excluding sites
Occupation Data Source	Death Certificates	Patient interviews, work history	Cancer Registry, not specified	Patient interview, work history	Hospital records
Outcome Data Source	Death Certificates	Not stated	Cancer registry, Massachusetts	Pathology Department records	
Case Selection Method		Not stated		All cases	
Control Selection Method		Not stated		Random	
Control Matching Criteria	Age (5 years), race	Hospital, age (5 years), year of interview		Age (5 years), region	Not stated
Number of Cases	Males: Females: Excluded	Male Firefighters = 2 Females: Excluded	Males = 315 Females: Excluded	Male Firefighters = 4 Females: Excluded	Male Police, Firemen and Protective Services = 60 Females: Excluded
Duration of Service		Min = 1 year Max = Not stated Mean = Not stated		Min = 6 months Max = Not stated Mean = Not stated	
Age at Hire					
Notes		<ul style="list-style-type: none"> ▪ 10% of initially eligible total were excluded 		<ul style="list-style-type: none"> • family history and cryptorchidism data available • 84 of total initially eligible were excluded 	<ul style="list-style-type: none"> ▪ 48% of initially eligible total were excluded ▪ Firefighters included as part of Police, Firemen, Protective Service Workers

* Studies not included in the quantitative analysis

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Table 3: Summary of Other Studies

Authors	Burnett C, et al. *	Firth HM, et al. *	Ma F, et. al. *	Morton & Marjanovic *	Grimes G, et al. *
Publication year	1994	1996	1998	1984	1991
Geographic Region	USA (27 states)	New Zealand	USA (24 states)	USA (Portland)	USA (Hawaii)
Outcome	Mortality	Incidence - cancer	Mortality	Incidence - leukemia	Mortality
Study Years (enrolment)	1984-90	1972-84	1984-1993	1963-77	1969-1988
Study Population	Deceased white male firefighters	Male firefighters diagnosed with cancer, aged 15 – 64 years	Deceased male firefighters	Cancer patients aged 16 –74 years	Deceased firefighters over the age of 20 years
Occupation Data Source	Death certificates	Cancer Registry – not stated	Death Certificates	Hospital records	Death certificates
Reference Population	Deceased white males from same regions	Males aged 15 – 64 years with full- or part-time work as stated on census	Deceased males, all causes except cancer	Population up to age 67 years	Deceased males, excluding firefighters, over the age of 20 years
Outcome Data Source	Death certificates	Cancer Registry	Death certificates	Hospital records and death certificates	Death certificates – slate of Hawaii
Total Subjects Included for Analysis	Males = 5744 Females: Excluded	Protective service workers = 401 Females : Excluded	Males = 1817 white males 66 black males Females: Excluded	Firefighters = 4	Males: 205
Total Subjects Excluded	Not stated	10% of total			Not stated
Duration of Service	Not available		Not available		Min = 1 year Max = Not stated Mean = Not stated
Age at Hire	Not available		Not available		Not available
Notes		<ul style="list-style-type: none"> ▪ Firefighters included as part of Protective Service Workers 			

* Studies not included in the quantitative analysis

Appendix B
Study Results by Cancer Site

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Brain and Nervous System Cancers									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Brownson RC, et al	1990	Case-control	191-192	OR	--	--	2.00	(0.40, 9.60)	
Krishnan G, et al	2003	Case-control	9380-9481~	OR	6	1	5.88	(0.70, 49.01)	Age >20, longest held job
Krishnan G, et al	2003	Case-control	9380-9481~	OR	9	3	2.85	(0.77, 10.58)	Age >20, ever worked as a firefighter
Bates M, et al	2000	Cohort	191*	SIR	5	3.9	1.27	(0.40, 3.00)	
Demers PA, et al	1994	Cohort	191*	SIR	4	3.6	1.10	(0.30, 2.90)	Reference General Population
Demers PA, et al	1994	Cohort	191	IDR	4		1.40	(0.20, 11.0)	Reference Population Police
Tornling G, et al	1994	Cohort	191*	SIR	5	3.7	1.37	(0.44, 3.20)	
Sama S, et al	1990	Case-control	191-192~	SMOR	5	--	0.86	(0.34, 2.15)	Reference Population State
Sama S, et al	1990	Case-control	191-192~	SMOR	5	--	1.52	(0.39, 5.92)	Reference Population Police
<u>Cancer Mortality Studies</u>									
Burnett C, et al	1994	Surveillance	191,192	PMR	19	--	0.85	(0.52, 1.34)	Age <65
Burnett C, et al	1994	Surveillance	191,192	PMR	38	--	1.03	(0.73, 1.41)	All ages
Beaumont J, et al	1991	Cohort	not stated	RR	5	--	0.81	(0.26, 1.90)	
Grimes G, et al	1991	Surveillance	191,192	RR	1.46%	0.39%	3.78	(1.22, 11.71)	
Ma F, et al	1998	Cohort	not stated	MOR	41		1	(0.80, 1.40)	White males
Ma F, et al	1998	Cohort	not stated	MOR	5		6.9	(3.0, 16.0)	Black males
Aronson KJ, et al	1994	Cohort	191-192	SMR	14	6.97	2.01	(1.10, 3.37)	
Baris D, et al	2001	Cohort	191-192	SMR	8	--	0.61	(0.31, 1.22)	
Bates M, et al	2000	Cohort	191*	SMR	2	3	0.68	(0.10, 2.40)	
Demers PA, et al	1992	Cohort	191,192	SMR	18	--	2.07	(1.23, 3.28)	Reference General Population
Demers PA, et al	1992	Cohort	191, 192	IDR	18		1.63	(0.70, 3.79)	Reference Population Police
Guidotti TL	1993	Cohort	191*	SMR	3	2.1	1.47	(0.30, 4.29)	
Musk AW, et al	1978	Cohort	193 (ICD7)	SMR	8	7.8	1.03	--	
Tornling G, et al	1994	Cohort	191*~	SMR	5	1.8	2.79	(0.91, 6.51)	
Vena & Fiedler	1987	Cohort	191,192	SMR	6	2.55	2.36	(0.86, 5.13)	

Shaded studies were eliminated as a result of quality assessment

* brain only ~ all cases were gliomas

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

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Digestive Organs

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Mortality Studies</u>									
Feuer & Rosenman	1986	Cohort	150-159	PMR	20	13.79	1.45	--	Reference US population
Feuer & Rosenman	1986	Cohort	150-159	PMR	20	21.95	0.91	--	Reference Population Police
Beaumont J, et al	1991	Cohort	not stated	RR	99	--	1.27	(1.04, 1.55)	
Grimes G, et al	1991	Surveillance	150-159	RR	8.78%	8.71%	1.01	(0.65, 1.57)	
Deschamps S, et al	1995	Cohort	150-159	SMR	5	--	1.14	(0.37, 2.66)	
Musk AW, et al	1978	Cohort	150-159 (ICD 7)	SMR	153	191.5	0.80	--	
Vena & Fiedler	1987	Cohort	150-159	SMR	39	28.2	1.38	(0.98, 1.89)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio
SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

Oesophagus

Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Bates M, et al	2000	Cohort	150	SIR	3	1.8	1.67	(0.30, 4.90)	
Demers PA, et al	1994	Cohort	150	SIR	4	3.1	1.30	(0.40, 3.30)	
<u>Cancer Mortality Studies</u>									
Beaumont J, et al	1991	Cohort	not stated	RR	12	--	2.04	(1.05, 3.57)	
Ma F, et al	1998	Cohort	not stated	MOR	37		0.9	(0.70, 1.30)	White males
Ma F, et al	1998	Cohort	not stated	MOR	4		1.4	--	Black males
Aronson KJ, et al	1994	Cohort	150	SMR	2	5.04	0.40	(0.05, 1.43)	
Baris D, et al	2001	Cohort	150	SMR	6	--	0.56	(0.25, 1.24)	
Demers PA, et al	1992	Cohort	150	SMR	6	--	0.83	(0.30, 1.80)	
Vena & Fiedler	1987	Cohort	150	SMR	3	2.2	1.34	(0.27, 3.91)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio
SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

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Stomach									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Bates M, et al	2000	Cohort	151	SIR	3	3.9	0.76	(0.20, 2.20)	
Demers PA, et al	1994	Cohort	151	SIR	8	5.8	1.40	(0.60, 2.70)	Reference General Population
Demers PA, et al	1994	Cohort	151	IDR	8		0.40	(0.10, 1.20)	Reference Population Police
Tornling G, et al	1994	Cohort	151	SIR	18	9.4	1.92	(1.14, 3.04)	
<u>Cancer Mortality Studies</u>									
Beaumont J, et al	1991	Cohort	not stated	RR	22	--	1.31	(0.82, 1.99)	
Grimes G, et al	1991	Surveillance	151	RR	1.95%	2.47%	0.79	(0.30, 2.09)	
Ma F, et al	1998	Cohort	not stated	MOR	52		1.2	(0.90, 1.70)	White males
Ma F, et al	1998	Cohort	not stated	MOR	3		1.2	--	Black males
Aronson KJ, et al	1994	Cohort	151	SMR	7	13.78	0.51	(0.20, 1.05)	
Baris D, et al	2001	Cohort	151	SMR	24	--	0.90	(0.61, 1.35)	
Bates M, et al	2000	Cohort	151	SMR	3	2.6	1.16	(0.20, 3.40)	
Demers PA, et al	1992	Cohort	151	SMR	16	--	1.07	(0.61, 1.73)	Reference General Population
Guidotti TL	1993	Cohort	151	SMR	6	7.4	0.81	(0.30, 1.76)	
Tornling G, et al	1994	Cohort	151	SMR	12	9.9	1.21	(0.62, 2.11)	
Vena & Fiedler	1987	Cohort	151	SMR	7	5.9	1.19	(0.48, 2.46)	
Eliopoulos E, et al	1984	Cohort	not stated	SPMR	5	--	2.02	(0.65, 4.70)	

Shaded studies were eliminated as a result of quality assessment

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SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

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Colon									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Bates M, et al	2000	Cohort	153	SIR	7	11.8	0.60	(0.20, 1.20)	
Demers PA, et al	1994	Cohort	153	SIR	23	21	1.10	(0.70, 1.60)	Reference General Population
Demers PA, et al	1994	Cohort	153	IDR	23		1.30	(0.60, 3.00)	Reference Population Police
Tornling G, et al	1994	Cohort	153	SIR	8	8.9	0.90	(0.39, 1.77)	
Sama S, et al	1990	Case-control	153	SMOR	33	--	1.20	(0.80, 1.82)	Reference Population State
Sama S, et al	1990	Case-control	153	SMOR	33	--	1.04	(0.59, 1.82)	Reference Population Police
<u>Cancer Mortality Studies</u>									
Beaumont J, et al	1991	Cohort	not stated*	RR	24	--	0.99	(0.63, 1.47)	
Grimes G, et al	1991	Surveillance	153	RR	2.44%	2.21%	0.91	(0.37, 2.20)	
Ma F, et al	1998	Cohort	not stated	MOR	149		1	(0.90, 1.20)	White males
Ma F, et al	1998	Cohort	not stated	MOR	9		2.1	(1.10, 4.0)	Black males
Aronson KJ, et al	1994	Cohort	153	SMR	11	18.24	0.60	(0.30, 1.08)	
Baris D, et al	2001	Cohort	153	SMR	64	--	1.51	(1.18, 1.93)	
Bates M, et al	2000	Cohort	153	SMR	6	5	1.19	(0.40, 2.60)	
Demers PA, et al	1992	Cohort	152, 153~	SMR	24	--	0.85	(0.54, 1.26)	Reference General Population
Demers PA, et al	1992	Cohort	152, 153	IDR	24		1.58	(0.73, 3.43)	Reference Population Police
Tornling G, et al	1994	Cohort	153	SMR	6	7.1	0.85	(0.31, 1.85)	
Vena & Fiedler	1987	Cohort	153	SMR	16	8.7	1.83	(1.05, 2.97)	

Shaded studies were eliminated as a result of quality assessment

*Intestine except rectum ~includes small intestine

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, IDR - Incidence Density Ratio, SMOR – Standardized Morbidity Odds Ratio, RR – RateRatio

Colorectal									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Giles G, et al	1993	Cohort	153, 154	SIR	9	--	1.36	(0.62, 2.59)	
Bates M, et al	2000	Cohort	153, 154 **	SIR	16	19.6	0.81	(0.50, 1.32)	
Demers PA, et al	1994	Cohort	153, 154 **	SIR	35	31.8	1.10	(0.79, 1.53)	
Tornling G, et al	1994	Cohort	153, 154 **	SIR	18	14.8	1.22	(0.77, 1.94)	
<u>Cancer Mortality Studies</u>									
Guidotti TL	1993	Cohort	152-154 ~	SMR	14	8.7	1.61	(0.88, 2.71)	
Eliopoulos E, et al	1984	Cohort	not stated*	SPMR	4	--	1.59	(0.43, 4.07)	
Beaumont J, et al	1991	Cohort	not stated **	RR	37	33.14	1.12	(0.81, 1.54)	
Aronson KJ, et al	1994	Cohort	153, 154 **	SMR	24	25.83	0.93	(0.62, 1.39)	
Baris D, et al	2001	Cohort	153, 154 **	SMR	78	56.52	1.38	(1.11, 1.72)	
Bates M, et al	2000	Cohort	153, 154 **	SMR	10	8.3	1.20	(0.65, 2.24)	
Demers PA, et al	1992	Cohort	153, 154 **	SMR	32	36.65	0.87	(0.62, 1.23)	
Tornling G, et al	1994	Cohort	153, 154 **	SMR	14	11	1.27	(0.75, 2.15)	
Vena & Fiedler	1987	Cohort	153, 154 **	SMR	23	12.1	1.90	(1.26, 2.86)	

** results reported for colon and rectal cancer cer combined for this analysis as described in the methods

* "Intestinal" and "rectal" ~includes small intestine

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Rectum									
Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Bates M, et al	2000	Cohort	154	SIR	9	7.8	1.15	(0.50, 2.20)	
Demers PA, et al	1994	Cohort	154	SIR	12	11.8	1.00	(0.50, 1.80)	Reference General Population
Demers PA, et al	1994	Cohort	154	IDR	12		1.30	(0.50, 3.90)	Reference Population Police
Tornling G, et al	1994	Cohort	154	SIR	10	5.9	1.70	(0.81, 3.12)	
Sama S, et al	1990	Case-control	154	SMOR	22	--	1.35	(0.84, 2.19)	Reference Population State
Sama S, et al	1990	Case-control	154	SMOR	22	--	0.97	(0.50, 1.88)	Reference Population Police
<u>Cancer Mortality Studies</u>									
Burnett C, et al	1994	Surveillance	154	PMR	18	--	1.86	(1.10, 2.94)	Age <65
Burnett C, et al	1994	Surveillance	154	PMR	37	--	1.48	(1.05, 2.05)	All ages
Beaumont J, et al	1991	Cohort	not stated	RR	13	--	1.45	(0.77, 2.49)	
Ma F, et al	1998	Cohort	not stated	MOR	27		1.1	(0.80, 1.60)	White males
Aronson KJ, et al	1994	Cohort	154	SMR	13	7.59	1.71	(0.91, 2.93)	
Baris D, et al	2001	Cohort	154	SMR	14	--	0.99	(0.59, 1.68)	
Bates M, et al	2000	Cohort	154	SMR	4	3.3	1.21	(0.30, 3.10)	
Demers PA, et al	1992	Cohort	154	SMR	8	--	0.95	(0.41, 1.87)	Reference General Population
Demers PA, et al	1992	Cohort	154	IDR	8		0.09	(0.30, 2.66)	Reference Population Police
Tornling G, et al	1994	Cohort	154	SMR	8	3.9	2.07	(0.89, 4.08)	
Vena & Fiedler	1987	Cohort	154	SMR	7	3.4	2.08	(0.83, 4.28)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

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Liver and gall bladder									
Study	Publication		ICD Codes	Measure ¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Tornling G, et al	1994	Cohort	155*	SIR	4	4.7	0.85	(0.23, 2.18)	
<u>Cancer Mortality Studies</u>									
Beaumont J, et al	1991	Cohort	not stated	RR	9	--	1.91	(0.87, 3.63)	
Ma F, et al	1998	Cohort	not stated	MOR	31		1.2	(0.90, 1.70)	White males
Aronson KJ, et al	1994	Cohort	155*	SMR	2	2.37	0.84	(0.10, 3.05)	
Baris D, et al	2001	Cohort	155, 156	SMR	8	--	0.82	(0.41, 1.64)	
Demers PA, et al	1992	Cohort	155.0-155.1, 156	SMR	6	--	1.19	(0.44, 2.59)	Reference General Population
Demers PA, et al	1992	Cohort	155.0-155.1, 156	IDR	6		0.71	(0.19, 2.71)	Reference Population Police
Tornling G, et al	1994	Cohort	155*	SMR	4	2.7	1.49	(0.41, 3.81)	
Vena & Fiedler	1987	Cohort	155, 156	SMR	2	2	0.98	(0.11, 3.52)	

Shaded studies were eliminated as a result of quality assessment

* liver only

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SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

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Pancreas									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Bates M, et al	2000	Cohort	157	SIR	3	2.3	1.28	(0.30, 3.70)	
Demers PA, et al	1994	Cohort	157	SIR	6	5.7	1.10	(0.40, 2.30)	Reference General Population
Demers PA, et al	1994	Cohort	157	IDR	6		1.10	(0.30, 5.50)	Reference Population Police
Giles G, et al	1993	Cohort	157	SIR	1	--	1.03	(0.01, 5.75)	
Tornling G, et al	1994	Cohort	157	SIR	6	5	1.19	(0.44, 2.60)	
Sama S, et al	1990	Case-control	157	SMOR	6	--	0.98	(0.42, 2.26)	Reference Population State
Sama S, et al	1990	Case-control	157	SMOR	6	--	3.19	(0.72, 14.20)	Reference Population Police
<u>Cancer Mortality Studies</u>									
Beaumont J, et al	1991	Cohort	not stated	RR	17	--	1.25	(0.73, 2.00)	
Ma F, et al	1998	Cohort	not stated	MOR	88		1.2	(1.00, 1.50)	White males
Ma F, et al	1998	Cohort	not stated	MOR	5		2	(0.90, 4.60)	Black males
Aronson KJ, et al	1994	Cohort	157	SMR	14	9.98	1.40	(0.77, 2.35)	
Baris D, et al	2001	Cohort	157	SMR	23	--	0.96	(0.64, 1.44)	
Demers PA, et al	1992	Cohort	157	SMR	14	--	0.89	(0.49, 1.49)	
Guidotti TL	1993	Cohort	157	SMR	5	3.22	1.55	(0.50, 3.62)	
Tornling G, et al	1994	Cohort	157	SMR	5	6	0.84	(0.27, 1.96)	
Vena & Fiedler	1987	Cohort	157	SMR	2	5.3	0.38	(0.04, 1.36)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

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Lymphatic and Haematopoietic Tissue									
Study	Publication Year	Study Design	ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
<u>Cancer Incidence Studies</u>									
Tornling G, et al	1994	Cohort	200-209	SIR	3	9.5	0.32	(0.06, 0.92)	
<u>Cancer Mortality Studies</u>									
Burnett C, et al	1994	Surveillance	200-208	PMR	85	--	1.61	(1.29, 1.99)	Age <65
Burnett C, et al	1994	Surveillance	200-208	PMR	169	--	1.30	(1.11, 1.51)	All ages
Beaumont J, et al	1991	Cohort	not stated	RR	14	--	0.65	(0.35, 1.09)	
Grimes G, et al	1991	Surveillance	200-209	RR	1.95%	2.06%	0.95	(0.36, 2.50)	
Aronson KJ, et al	1994	Cohort	200-208	SMR	18	18.29	0.98	(0.58, 1.56)	
Bates M, et al	2000	Cohort	200-208	SMR	4	5.6	0.72	(0.20, 1.80)	
Demers PA, et al	1992	Cohort	200-208	SMR	37	--	1.31	(0.92, 1.81)	Reference General Population
Demers PA, et al	1992	Cohort	200-208	IDR	37	--	1.03	(0.62, 1.73)	Reference Population Police
Guidotti TL	1993	Cohort	200-208	SMR	10	7.9	1.27	(0.61, 2.33)	
Musk AW, et al	1978	Cohort	200-205(ICD 7)	SMR	22	34.9	0.63	--	
Tornling G, et al	1994	Cohort	200-209	SMR	3	6.9	0.44	(0.09, 1.27)	
Vena & Fiedler	1987	Cohort	200-209	SMR	5	9.05	0.55	(0.18, 1.29)	
Eliopoulos E, et al	1984	Cohort	not stated	SPMR	3	--	1.88	(0.39, 5.50)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

Lymphosarcoma and reticulosarcoma									
Study	Publication Year	Study Design	ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
<u>Cancer Mortality Studies</u>									
Beaumont J, et al	1991	Cohort	not stated	RR	4	--	0.89	(0.24, 2.29)	
Demers PA, et al	1992	Cohort	200	SMR	7	--	1.42	(0.57, 2.93)	Reference General Population
Demers PA, et al	1992	Cohort	200	IDR	7	--	0.81	(0.30, 2.22)	Reference Population Police

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

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Multiple Myeloma									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Demers PA, et al	1993	Case-control	not stated	OR	5	5	1.90	(0.50, 9.40)	
Demers PA, et al	1994	Cohort	203	SIR	2	2.8	0.70	(0.10, 2.60)	
<u>Cancer Mortality Studies</u>									
Burnett C, et al	1994	Surveillance	203	PMR	11	--	1.36	(0.68, 2.43)	Age <65
Burnett C, et al	1994	Surveillance	203	PMR	34	--	1.48	(1.02, 2.07)	All ages
Ma F, et al	1998	Cohort	not stated	MOR	28		1.1	(0.80, 1.60)	White males
Ma F, et al	1998	Cohort	not stated	MOR	1		0.8	--	Black males
Baris D, et al	2001	Cohort	203	SMR	10	--	1.68	(0.90, 3.11)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio
SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

Leukemia									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Demers PA, et al	1994	Cohort	204-208	SIR	6	6.2	1.00	(0.40, 2.10)	Reference General Population
Demers PA, et al	1994	Cohort	204-208	IDR	6		0.80	(0.20, 3.50)	Reference Population Police
Giles G, et al	1993	Cohort	204-208	SIR	0	--	0.00	(0.00, 3.56)	
Morton & Marjanovic	1984	Surveillance	not stated	SIR	4.00	1.20	3.46	p<0.01	
Sama S, et al	1990	Case-control	H 980-994, excl. 984	SMOR	6	--	1.12	(0.48, 2.59)	Reference Population State
Sama S, et al	1990	Case-control	H 980-994, excl. 984	SMOR	6	--	2.67	(0.62, 11.54)	Reference Population Police
<u>Cancer Mortality Studies</u>									
Burnett C, et al	1994	Surveillance	204-208	PMR	33	--	1.71	(1.18, 2.40)	Age <65
Burnett C, et al	1994	Surveillance	204-208	PMR	61	--	1.19	(0.91, 1.53)	All ages
Feuer & Rosenman	1986	Cohort	204-207	PMR	4	2.15	1.86	--	Reference US population
Feuer & Rosenman	1986	Cohort	204-207	PMR	4	1.45	2.76	p<0.05	Reference Population Police
Beaumont J, et al	1991	Cohort	not stated	RR	6	--	0.61	(0.22, 1.33)	
Ma F, et al	1998	Cohort	not stated	MOR	60		1.1	(0.80, 1.40)	White males
Baris D, et al	2001	Cohort	204-207	SMR	15	--	0.83	(0.50, 1.37)	
Demers PA, et al	1992	Cohort	204-208	SMR	15	--	1.27	(0.71, 2.09)	Reference General Population
Demers PA, et al	1992	Cohort	204-208	IDR	15		0.80	(0.38, 1.70)	Reference Population Police

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio
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Hodgkin's Disease

Study	Publication Year	Study Design	ICD Codes	Measure ¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
<u>Cancer Incidence Studies</u>									
Demers PA, et al	1994	Cohort	201	SIR	1	1.4	0.70	(0.00, 4.10)	
<u>Cancer Mortality Studies</u>									
Ma F, et al	1998	Cohort	not stated	MOR	13		2.4	(1.40, 4.10)	White males
Demers PA, et al	1992	Cohort	201	SMR	3	--	1.05	(0.22, 3.08)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

non-Hodgkins Lymphoma

Study	Publication Year	Study Design	ICD Codes	Measure ¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
<u>Cancer Incidence Studies</u>									
Demers PA, et al	1994	Cohort	200-202	SIR	7	7.7	0.90	(0.40, 1.90)	Reference General Population
Demers PA, et al	1994	Cohort	200-202	IDR	7		1.80	(0.40, 13.0)	Reference Population Police
Giles G, et al	1993	Cohort	200, 202	SIR	4	--	1.85	(0.50, 4.74)	
Sama S, et al	1990	Case-control	H 959-964, 967-970, 972, 975-976	SMOR	14	--	1.59	(0.89, 2.84)	Reference Population State
Sama S, et al	1990	Case-control	H 959-964, 967-970, 972, 975-976	SMOR	14	--	3.27	(1.19, 8.98)	Reference Population Police
<u>Cancer Mortality Studies</u>									
Figgs LW, et al	1995	Case-control	200, 202 excl. 202.3 and 202.6	OR	12	--	5.60	(2.50, 12.30)	
Burnett C, et al	1994	Surveillance	200, 202	PMR	35	--	1.61	(1.12, 2.24)	Age <65
Burnett C, et al	1994	Surveillance	200, 202	PMR	66	--	1.32	(1.02, 1.67)	All ages
Ma F, et al	1998	Cohort	not stated	MOR	76		1.4	(1.10, 1.70)	White males
Ma F, et al	1998	Cohort	not stated	MOR	1		0.8	--	Black males
Baris D, et al	2001	Cohort	200, 202	SMR	20	--	1.41	(0.91, 2.19)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

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Melanoma of skin									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Bates M, et al	2000	Cohort	172	SIR	23	18.3	1.26	(0.80, 1.90)	
Demers PA, et al	1994	Cohort	172	SIR	9	7.4	1.20	(0.60, 2.30)	Reference General Population
Demers PA, et al	1994	Cohort	172	IDR	9		1.00	(0.40, 1.80)	Reference Population Police
Giles G, et al	1993	Cohort	172	SIR	5	--	1.08	(0.35, 2.53)	
Tornling G, et al	1994	Cohort	172	SIR	2	2.5	0.79	(0.09, 2.87)	
Sama S, et al	1990	Case-control	173, H 872-879	SMOR	18	--	2.92	(1.70, 5.03)	Reference Population State
Sama S, et al	1990	Case-control	173, H 872-879	SMOR	18	--	1.38	(0.60, 3.19)	Reference Population Police
<u>Cancer Mortality Studies</u>									
Burnett C, et al	1994	Surveillance	172	PMR	24	--	1.67	(1.07, 2.48)	Age <65
Burnett C, et al	1994	Surveillance	172	PMR	38	--	1.63	(1.15, 2.23)	All ages
Ma F, et al	1998	Cohort	not stated	MOR	35		1.4	(1.0, 1.90)	White males
Aronson KJ, et al	1994	Cohort	172	SMR	2	2.75	0.73	(0.09, 2.63)	
Bates M, et al	2000	Cohort	172	SMR	2	3.1	0.65	(0.10, 2.40)	
Guidotti TL	1993	Cohort	172	SMR	0	1.1	0.00	(0.00, 331.2)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

Skin (melanoma and non-melanoma)									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Tornling G, et al	1994	Cohort	173*	SIR	5	3.3	1.51	(0.49, 3.53)	
<u>Cancer Mortality Studies</u>									
Feuer & Rosenman	1986	Cohort	172,173	PMR	4	1.48	2.70	p<0.05	Reference US population
Feuer & Rosenman	1986	Cohort	172,173	PMR	4	2.96	1.35	--	Reference Population Police
Beaumont J, et al	1991	Cohort	not stated ~	RR	7	--	1.69	(0.68, 3.49)	
Ma F, et al	1998	Cohort	not stated ~	MOR	9		1	(0.50, 1.90)	White males
Baris D, et al	2001	Cohort	172,173	SMR	10	--	1.18	(0.64, 2.20)	
Demers PA, et al	1992	Cohort	172,173	SMR	6	--	0.98	(0.36, 2.13)	Reference General Population
Demers PA, et al	1992	Cohort	172, 173	IDR	6		1.12	(0.27, 4.76)	Reference Population Police

Shaded studies were eliminated as a result of quality assessment

* non melanoma only ~ skin not otherwise stated

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Oral and Pharynx									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Demers PA, et al	1994	Cohort	140-149	SIR	11	9.9	1.10	(0.60, 2.00)	Reference General Population
Demers PA, et al	1994	Cohort	140-149	IDR	11	0.8		(0.3, 1.9)	Reference Population Police
<u>Cancer Mortality Studies</u>									
Beaumont J, et al	1991	Cohort	not stated	RR	11	--	1.43	(0.71, 2.57)	
Aronson KJ, et al	1994	Cohort	146-149*	SMR	4	2.87	1.39	(0.38, 3.57)	
Baris D, et al	2001	Cohort	140-149	SMR	19	--	1.36	(0.87, 2.14)	
Demers PA, et al	1992	Cohort	140-149	SMR	7	--	0.81	(0.33, 1.66)	
Deschamps S, et al	1995	Cohort	140-149	SMR	2	--	0.81	(0.10, 2.93)	
Guidotti TL	1993	Cohort	140-149	SMR	2	1.8	1.14	(0.14, 4.10)	

Shaded studies were eliminated as a result of quality assessment

* pharynx only

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Genito-urinary organs									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Giles G, et al	1993	Cohort	188, 189*	SIR	4	--	1.02	(0.28, 2.62)	
<u>Cancer Mortality Studies</u>									
Beaumont J, et al	1991	Cohort	not stated	RR	9	--	0.40	(0.18, 0.77)	
Grimes G, et al	1991	Surveillance	179-189	RR	5.37%	2.35%	2.28	(1.28, 4.06)	
Deschamps S, et al	1995	Cohort	180-189	SMR	2	--	3.29	(0.40, 11.88)	
Musk AW, et al	1978	Cohort	177-181 (ICD 7)	SMR	64	69.6	0.92	--	
Eliopoulos E, et al	1984	Cohort	not stated	SPMR	4	--	1.08	(0.29, 2.76)	

Shaded studies were eliminated as a result of quality assessment

* Urinary Tract

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

Bladder									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Bates M, et al	2000	Cohort	188	SIR	5	4.4	1.14	(0.40, 2.70)	
Demers PA, et al	1994	Cohort	188	SIR	18	15.3	1.20	(0.70, 1.90)	Reference General Population
Demers PA, et al	1994	Cohort	188	IDR	18	--	1.70	(0.70, 4.30)	Reference Population Police
Sama S, et al	1990	Case-control	188	SMOR	26	--	1.59	(1.02, 2.50)	Reference Population State
Sama S, et al	1990	Case-control	188	SMOR	26	--	2.11	(1.07, 4.14)	Reference Population Police
<u>Cancer Mortality Studies</u>									
Burnett C, et al	1994	Surveillance	188	PMR	37	--	0.99	(0.70, 1.37)	All ages
Burnett C, et al	1994	Surveillance	188	PMR	9	--	1.01	(0.46, 1.93)	Age <65
Beaumont J, et al	1991	Cohort	not stated*	RR	5	--	0.57	(0.19, 1.35)	
Ma F, et al	1998	Cohort	not stated	MOR	48	--	1.2	(0.90, 1.60)	White males
Ma F, et al	1998	Cohort	not stated	MOR	1	--	1.3	--	Black males
Aronson KJ, et al	1994	Cohort	188	SMR	7	5.49	1.28	(0.51, 2.63)	
Baris D, et al	2001	Cohort	188	SMR	17	--	1.25	(0.77, 2.00)	
Bates M, et al	2000	Cohort	188	SMR	2	0.7	2.73	(0.30, 9.80)	
Demers PA, et al	1992	Cohort	188, 189.3-189.9*	SMR	2	--	0.23	(0.03, 0.83)	Reference General Population
Demers PA, et al	1992	Cohort	188, 189.3-189.9	IDR	2	--	0.16	(0.02, 1.24)	Reference Population Police
Guidotti TL	1993	Cohort	188	SMR	4	1.3	3.15	(0.86, 8.08)	
Vena & Fiedler	1987	Cohort	188	SMR	9	3.15	2.86	(1.30, 5.40)	

Shaded studies were eliminated as a result of quality assessment

* Bladder and other urinary

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SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

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Kidney									
Study	Publication Year	Study Design	ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
<u>Cancer Incidence Studies</u>									
Delahunt B, et al	1995	Case-control	189	OR	--	--	3.51	(2.09, 5.92)	
Bates M, et al	2000	Cohort	189	SIR	2	3.5	0.57	(0.10, 2.10)	
Demers PA, et al	1994	Cohort	189	SIR	3	5.6	0.50	(0.10, 1.60)	Reference General Population
Demers PA, et al	1994	Cohort	189	IDR	3		0.40	(0.10, 2.10)	Reference Population Police
Tornling G, et al	1994	Cohort	189	SIR	2	5.6	0.36	(0.04, 1.29)	
<u>Cancer Mortality Studies</u>									
Burnett C, et al	1994	Surveillance	189.0-189.2*	PMR	24	--	1.41	(0.90, 2.10)	All ages
Burnett C, et al	1994	Surveillance	189.0-189.2*	PMR	53	--	1.44	(1.08, 1.89)	Age <65
Beaumont J, et al	1991	Cohort	not stated~	Rate Ratio	4	--	0.68	(0.19, 1.74)	
Ma F, et al #	1998	Cohort	not stated	MOR	49		1.3	(1.00, 1.70)	White males
Aronson KJ, et al	1994	Cohort	189	SMR	2	4.63	0.43	(0.05, 1.56)	
Baris D, et al	2001	Cohort	189	SMR	12	--	1.07	(0.61, 1.88)	
Demers PA, et al	1992	Cohort	189.0-189.2*	SMR	2	--	0.27	(0.03, 0.97)	
Guidotti TL	1993	Cohort	189	SMR	7	1.7	4.14	(1.66, 8.53)	
Tornling G, et al	1994	Cohort	189	SMR	4	3.7	1.10	(0.30, 2.81)	
Vena & Fiedler	1987	Cohort	189	SMR	3	2.3	1.30	(0.26, 3.80)	

Shaded studies were eliminated as a result of quality assessment

* Kidney and Ureter ~Kidney excluding other urinary #Kidney and renal pelvis

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Prostate									
Study	Publication Year	Study Design	ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
<u>Cancer Incidence Studies</u>									
Krstev S, et al	1998	Case-control	not stated	OR	10	5	3.34	(1.13, 9.91)	
Bates M, et al	2000	Cohort	185	SIR	11	10.2	1.08	(0.50, 1.90)	
Demers PA, et al	1994	Cohort	185	SIR	66	48.3	1.40	(1.10, 1.70)	Reference General Population
Demers PA, et al	1994	Cohort	185	IDR	66		1.10	(0.70, 1.80)	Reference Population Police
Giles G, et al	1993	Cohort	185	SIR	5	--	2.09	(0.67, 4.88)	
Tornling G, et al	1994	Cohort	185	SIR	28	24.5	1.14	(0.76, 1.65)	
<u>Cancer Mortality Studies</u>									
Beaumont J, et al	1991	Cohort	not stated	RR	8	--	0.38	(0.16, 0.75)	
Grimes G, et al	1991	Surveillance	185	RR	4.39%	1.68%	2.61	(1.38, 4.97)	
Ma F, et al	1998	Cohort	not stated	MOR	189		1.2	(1.00, 1.30)	White males
Ma F, et al	1998	Cohort	not stated	MOR	16		1.9	(1.20, 3.20)	Black males
Aronson KJ, et al	1994	Cohort	185	SMR	16	12.09	1.32	(0.76, 2.15)	
Baris D, et al	2001	Cohort	185	SMR	31	--	0.96	(0.68, 1.37)	
Demers PA, et al	1992	Cohort	185	SMR	30	--	1.34	(0.90, 1.91)	Reference General Population
Demers PA, et al	1992	Cohort	185	IDR	30		1.43	(0.71, 2.85)	Reference Population Police
Guidotti TL	1993	Cohort	185	SMR	8	5.5	1.46	(0.63, 2.88)	
Tornling G, et al	1994	Cohort	185	SMR	14	11.6	1.21	(0.66, 2.02)	
Vena & Fiedler	1987	Cohort	185	SMR	5	7.1	0.71	(0.23, 1.65)	

Shaded studies were eliminated as a result of quality assessment

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SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

Testis									
Study	Publication Year	Study Design	ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
<u>Cancer Incidence Studies</u>									
Stang A, et al	2003	Case-control	not stated	OR	4	3	4.30	(0.70, 30.5)	
Bates M, et al	2000	Cohort	186	SIR	11	7.1	1.55	(0.80, 2.80)	
Giles G, et al	1993	Cohort	186	SIR	2	--	1.15	(0.13, 4.17)	
<u>Cancer Mortality Studies</u>									
Ma F, et al	1998	Cohort	not stated	MOR	1		0.6	--	White males
Aronson KJ, et al	1994	Cohort	186	SMR	3	1.19	2.52	(0.52, 7.37)	

Shaded studies were eliminated as a result of quality assessment

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Respiratory									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Mortality Studies</u>									
Feuer & Rosenman	1986	Cohort	160-163	PMR	23	23.5	0.98	--	Reference US population
Feuer & Rosenman	1986	Cohort	160-163	PMR	23	22.63	1.02	--	Reference Population Police
Beaumont J, et al	1991	Cohort	not stated	RR	63	--	0.83	(0.64, 1.06)	
Grimes G, et al	1991	Surveillance	160-163	RR	8.78%	6.85%	1.28	(0.82, 2.00)	
Deschamps S, et al	1995	Cohort	160-165	SMR	7	--	1.12	(0.45, 2.30)	
Eliopoulos E, et al	1984	Cohort	not stated	SMR	7	--	0.84	(0.33, 1.71)	
Musk AW, et al	1978	Cohort	160-165 (ICD 7)	SMR	70	79.6	0.88	--	
Vena & Fiedler	1987	Cohort	160-163	SMR	28	29.8	0.94	(0.62, 1.36)	
Eliopoulos E, et al	1984	Cohort	not stated	SPMR	7	--	1.04	(0.42, 2.13)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio, OR – Odds Ratio

Lung									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk Estimate	95% CI	Notes
	Year	Study Design							
<u>Cancer Incidence Studies</u>									
Zahn S, et al	1989	Case-control	162	OR	--	--	1.60	(1.10, 2.30)	
Bates M, et al	2000	Cohort	162	SIR	17	15	1.14	(0.70, 1.80)	
Demers PA, et al	1994	Cohort	162	SIR	45	46.8	1.00	(0.70, 1.30)	Reference General Population
Demers PA, et al	1994	Cohort	162	IDR	45	--	1.10	(0.60, 1.90)	Reference Population Police
Firth HM, et al	1996	Surveillance	not stated	SIR	--	--	1.27	(0.46, 2.78)	
Giles G, et al	1993	Cohort	162	SIR	6	--	0.77	(0.28, 1.68)	
Tornling G, et al	1994	Cohort	162	SIR	16	17.9	0.89	(0.51, 1.45)	
Sama S, et al	1990	Case-control	162	SMOR	71	--	1.22	(0.87, 1.69)	Reference Population State
Sama S, et al	1990	Case-control	162	SMOR	71	--	1.30	(0.84, 2.03)	Reference Population Police
<u>Cancer Mortality Studies</u>									
Burnett C, et al	1994	Surveillance	162	PMR	236	--	0.98	(0.86, 1.12)	Age <65
Burnett C, et al	1994	Surveillance	162	PMR	562	--	1.02	(0.94, 1.11)	All ages
Beaumont J, et al	1991	Cohort	162	RR	60	--	0.84	(0.64, 1.08)	
Ma F, et al	1998	Cohort	not stated	MOR	633	--	1.1	(1.00, 1.20)	White males
Ma F, et al	1998	Cohort	not stated	MOR	15	--	0.8	(0.50, 1.30)	Black males
Aronson KJ, et al	1994	Cohort	162	SMR	54	57.07	0.95	(0.71, 1.24)	
Baris D, et al	2001	Cohort	162	SMR	162	--	1.13	(0.97, 1.32)	
Bates M, et al	2000	Cohort	162	SMR	10	11.7	0.86	(0.40, 1.60)	
Demers PA, et al	1992	Cohort	162	SMR	95	--	0.96	(0.77, 1.17)	Reference General Population
Demers PA, et al	1992	Cohort	162	IDR	95	--	0.95	(0.67, 1.33)	Reference Population Police
Guidotti TL	1993	Cohort	162	SMR	24	16.9	1.42	(0.91, 2.11)	
Hansen ES	1990	Cohort	162	SMR	9	--	1.63	(0.75, 3.10)	
Tornling G, et al	1994	Cohort	162	SMR	18	20.1	0.90	(0.53, 1.42)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, IDR - Incidence Density Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio

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Larynx									
Study	Publication		ICD Codes	Measure¹	Observed /Cases	Expected /Controls	Risk		Notes
	Year	Study Design					Estimate	95% CI	
<u>Cancer Incidence Studies</u>									
Muscat & Wynder	1995	Case-control	not stated	OR	2	2	--	--	
Demers PA, et al	1994	Cohort	161	SIR	5	5.1	1.00	(0.30, 2.30)	Reference General Population
Demers PA, et al	1994	Cohort	161	IDR	5		0.80	(0.20, 3.50)	Reference Population Police
Firth HM, et al	1996	Surveillance	not stated	SIR	--	--	13.48	(2.54, 39.91)	
<u>Cancer Mortality Studies</u>									
Beaumont J, et al	1991	Cohort	not stated	RR	3	--	0.80	(0.17, 2.35)	
Ma F, et al	1998	Cohort	not stated	MOR	13		0.8	(0.40, 1.30)	White males
Aronson KJ, et al	1994	Cohort	161	SMR	1	2.7	0.37	(0.01, 2.06)	
Baris D, et al	2001	Cohort	161	SMR	5	--	0.75	(0.31, 1.81)	
Demers PA, et al	1992	Cohort	161	SMR	2	--	0.47	(0.06, 1.70)	

Shaded studies were eliminated as a result of quality assessment

¹ SMR – Standardized Mortality Ratio, SIR – Standardized Incidence Ratio, PMR – Proportional Mortality Ratio, SPMR - Standardized Proportional Mortality Ratio

SMOR – Standardized Morbidity Odds Ratio, OR – Odds Ratio, RR – RateRatio