1997-98 SESSION COMMITTEE HEARING RECORDS

Committee Name:

Joint Survey Committee on Retirement Systems (JSC-RS)

Sample:

- Record of Comm. Proceedings
- 97hrAC-EdR_RCP_pt01a
- 97hrAC-EdR_RCP_pt01b
- 97hrAC-EdR_RCP_pt02

- *Appointments* ... *Appt*
-
- *Clearinghouse Rules* ... *CRule*
-
- *Committee Hearings* ... *CH*
-
- *Committee Reports* ... *CR*
-
- *Executive Sessions* ... *ES*
-
- *Hearing Records* ... *HR*
-
- *Miscellaneous* ... *Misc*
- *97hr_JSC-RS_Misc_pt04d*
- *Record of Comm. Proceedings* ... *RCP*
-

cancer
presumption

PROFESSIONAL FIRE FIGHTERS OF WISCONSIN, INC.

CANCER PRESUMPTION LEGISLATION

MAJOR PROVISIONS

1.	**Who is covered?** All municipal fire fighters, including both those in the city of Milwaukee and by Milwaukee County.

2.	**What cancers are covered?** Skin, breasts, central nervous system or lymphatic, digestive, hematological, urinary, skeletal, oral or reproductive systems.

3.	**Is lung cancer covered?** Lung cancer is already covered by the existing Heart and Lung Bill so it is not listed in the new cancer presumption bill.

4.	**How many years must a fire fighter be employed before eligible for cancer presumption?** Ten

5.	**What level of benefit would be available for the surviving family if the fire fighter dies?** Seventy (70) percent of the participant's salary or benefit at time of death. Under the current Heart and Lung Bill, surviving spouse receives fifty (50) percent and each minor child ten (10 percent up to a maximum of seventy (70) percent for the entire family.

6.	**Could a fire fighter receive both the proposed cancer presumption benefit and withdraw their separation benefit from the Wisconsin Retirement System?** Unlike the Heart and Lung Bill, a fire fighter will not be able to withdraw their separation benefit if they utilize the cancer presumption.

STATES WITH

CANCER PRESUMPTION LAWS

ALABAMA

CALIFORNIA

ILLINOIS

LOUISIANA

MARYLAND

MASSACHUSETTS

MINNESOTA

MISSOURI

NEBRASKA

NEVADA

NEW HAMPSHIRE

NORTH DAKOTA

OKLAHOMA

RHODE ISLAND

TENNESSEE

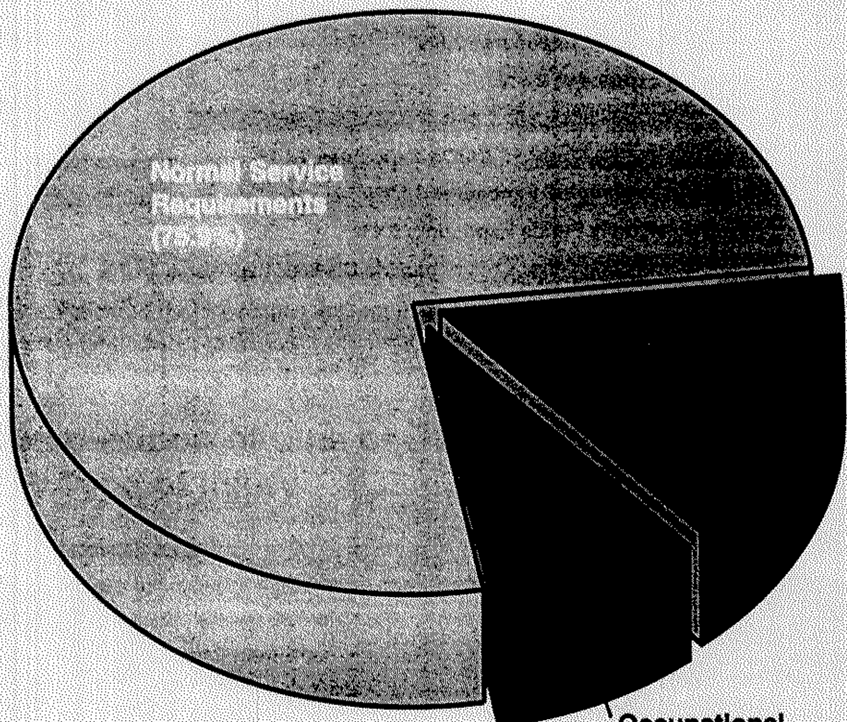
TEXAS

VIRGINIA

IV. Fire Fighter Line of Duty Injury and Occupational Disease Retirements

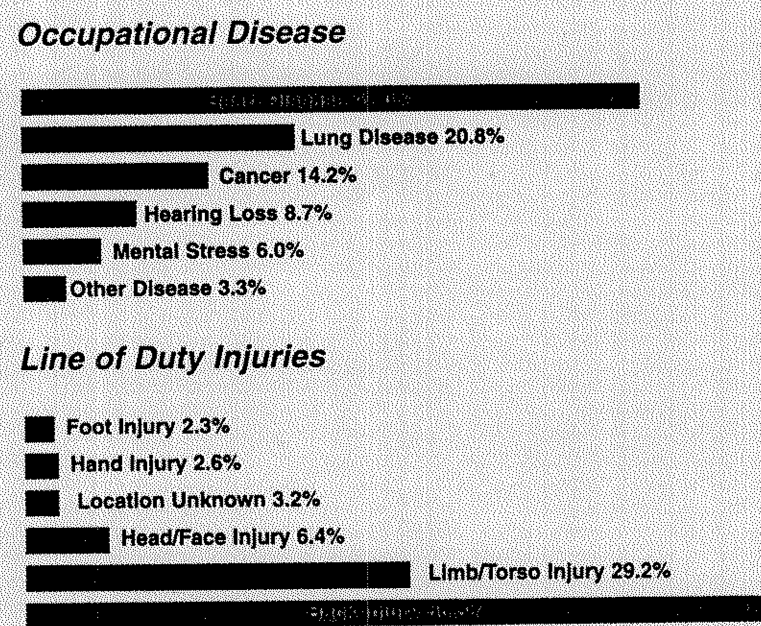
As reported in this year's survey, 526 fire fighters were forced to retire from their departments because of line-of-duty injuries or occupational disease—representing nearly 1 in 4 fire fighter retirements. The average age for duty connected disability retirements was 48 years for injury and 53 years for occupational disease.

Distribution of Fire Fighter Retirements



The leading causes of premature departures in the case of occupationally related disease were heart disease and lung disease, while back injury, followed closely by limb/torso injury, were the primary reasons for job related injury retirements.

Breakdown of Line of Duty Disability Retirements by Cause



State of Wisconsin
1997 – 1998 LEGISLATURE

LRB–1538/3
RAC:mfd&jlg:arm

1997 BILL

AN ACT ***to amend*** 40.25 (2), 40.25 (2m), 61.66 (2), 111.35 (4) and 891.45; and ***to create*** 40.25 (2t), 40.65 (7) (ar) and 891.455 of the statutes; **relating to:** presumption concerning employment–connected disease for certain municipal fire fighters.

Analysis by the Legislative Reference Bureau

Under current law, in any proceeding involving the application by a municipal fire fighter or his or her beneficiary for any disability or death benefit, where at the time of death or filing of application for disability benefits the deceased or disabled fire fighter had served a total of 5 years as a fire fighter and a qualifying medical examination given before the time of his or her joining the fire department showed no evidence of *heart or respiratory impairment or disease*, and where the disability or death is found to be caused by heart or respiratory impairment or disease, this finding shall be presumptive evidence that such impairment or disease was caused by his or her employment as a fire fighter.

This bill provides a new presumption for municipal fire fighters. Under the bill, in any proceeding involving the application by a municipal fire fighter or his or her beneficiary for disability or death benefits, where at the time of death or filing of application for disability benefits the deceased or disabled fire fighter had served a total of 10 years as a fire fighter and a qualifying medical examination given before the time of his or her joining the fire department showed no evidence of *cancer*, and where the disability or death is found to be caused by cancer, this finding shall be presumptive evidence that the cancer was caused by his or her employment as a fire fighter. Under the bill, this presumption only applies to cancers affecting the skin, breasts, central nervous system or lymphatic, digestive, hematological, urinary, skeletal, oral or reproductive systems.

This bill will be referred to the joint survey committee on retirement systems for a detailed analysis, which will be printed as an appendix to this bill.

For further information see the ***state and local*** fiscal estimate, which will be printed as an appendix to this bill.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. 40.25 (2) of the statutes is amended to read:

40.25 **(2)** ~~If~~ Subject to subs. (2m) and (2t), if all requirements for payment of a retirement annuity are met except attainment of age 55 or age 50 for protective occupation participants, a separation benefit may be paid, if the participant's written application for a separation benefit is received by the department prior to the participant's 55th birthday or 50th birthday for protective occupation participants, in an amount equal to the additional and employe required contribution accumulations of the participant on the date the application for a separation benefit is approved.

SECTION 2. 40.25 (2m) of the statutes is amended to read:

40.25 **(2m)** ~~Notwithstanding sub. (2), if~~ If a participant who is initially covered under the Wisconsin retirement system on or after January 1, 1990, terminates employment and does not have creditable service in at least 5 calendar years, a separation benefit may be paid if the participant submits a written application to the department for a separation benefit in an amount equal to the additional and employe required contribution accumulations of the participant on the date that the application for a separation benefit is approved. For the purposes of this subsection there are no age requirements for receiving a separation benefit.

SECTION 3. 40.25 (2t) of the statutes is created to read:

40.25 **(2t)** A protective occupation participant who is covered by the presumption under s. 891.455 and who applied for a duty disability benefit under s. 40.65 on or after the effective date of this subsection .... [revisor inserts date], may not be paid a separation benefit under sub. (2) or (2m) during the period in which he or she is receiving the duty disability benefit.

SECTION 4. 40.65 (7) (ar) of the statutes is created to read:

40.65 **(7)** (ar) 1. This paragraph applies to benefits based on applications filed on or after the effective date of this subdivision .... [revisor inserts date]. If a protective occupation participant, who is covered by the presumption under s. 891.455, dies as a result of an injury or a disease for which a benefit is paid or would be payable under sub. (4), and the participant is survived by a spouse or an unmarried child under the age of 18, a monthly benefit shall be paid as follows:

a. To the surviving spouse until the surviving spouse remarries, if the surviving spouse was married to the participant on the date that the participant was disabled under sub. (4), 70% of the participant's monthly salary at the time of death, but reduced by any amount payable under sub. (5) (b) 1. to 6.

b. If there is no surviving spouse or the surviving spouse subsequently dies, to a guardian for each of that guardian's wards who is an unmarried surviving child under the age of 18, 10% of the participant's monthly salary at the time of death, payable until the child marries, dies or reaches the age of 18, whichever occurs first.

2. Benefits payable under this paragraph shall be increased each January 1 by the salary index determined for the prior year.

SECTION 5. 61.66 (2) of the statutes is amended to read:

SECTION 8. 891.455 of the statutes is created to read:

891.455 Presumption of employment–connected disease; cancer (1) In this section, "municipal fire fighter" means a municipal fire fighter who is covered under s. 891.45 and any person under s. 61.66 whose duties as a fire fighter during the 10–year qualifying period specified in sub. (2) took up at least two–thirds of his or her working hours.

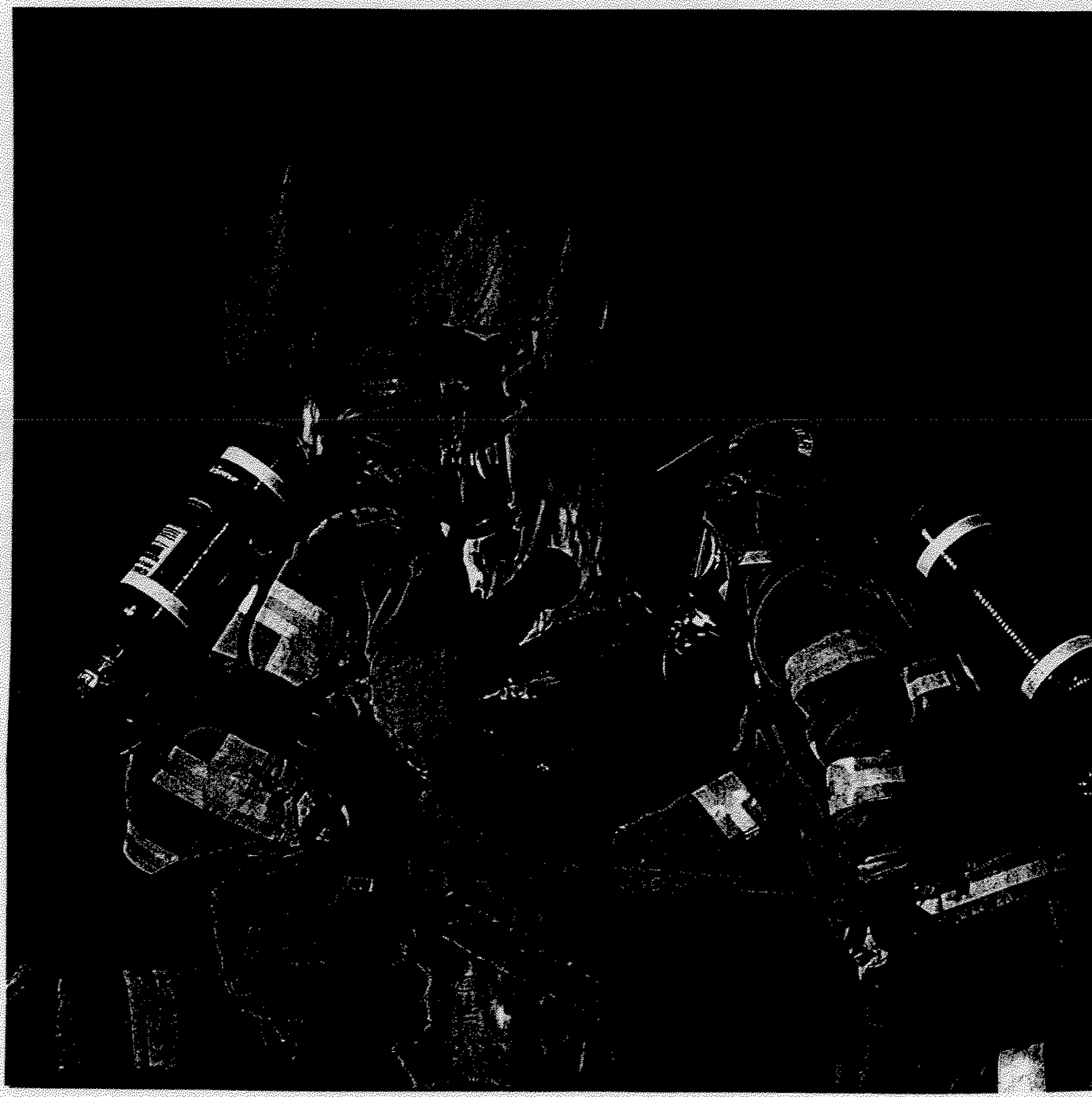
(2) Beginning with applications submitted by a municipal fire fighter or his or her beneficiary on the effective date of this subsection .... [revisor inserts date], in any proceeding involving an application by a municipal fire fighter or his or her beneficiary for disability or death benefits under s. 66.191, 1981 stats., or s. 40.65 (2) or any pension or retirement system applicable to fire fighters, where at the time of death or filing of application for disability benefits the deceased or disabled municipal fire fighter had served a total of 10 years as a municipal fire fighter and a qualifying medical examination given prior to the time of his or her joining the department showed no evidence of cancer, and where the disability or death is found to be caused by cancer, such finding shall be presumptive evidence that the cancer was caused by such employment.

(3) The presumption under sub. (2) shall only apply to cancers affecting the skin, breasts, central nervous system or lymphatic, digestive, hematological, urinary, skeletal, oral or reproductive systems.

(END)

CANCER PRESUMPTION

LEGISLATION



CANCER PRESUMPTION LEGISLATION

Recognizing that fire fighters suffered an inordinate amount of heart disease due to the stress of fire fighting, the Wisconsin Legislature enacted legislation in 1961 that determined that any disability or death due to heart or respiratory impairment or disease would automatically be presumed to have been caused by fire fighting. Thus such individuals would automatically be eligible for Duty Disability benefits.

Most states in the United States now have such legislation. Studies by the International Association of Fire Fighters (IAFF) conclude that over 50 percent of duty disability retirements are caused by heart disease.

Similar IAFF studies have indicated that cancer is the second leading cause of fire fighter early retirements. To date, eight states have enacted similar legislation that "presumes" that if a fire fighter develops cancer it is due to their occupation and thus eligible for the duty disability retirement benefit.

The Wisconsin Legislature has not yet considered such legislation. However, the PFFW is seeking such legislation in the 1997-98 session.

The risks of fire fighters developing cancer due to their occupation increases daily. By reason of their employment fire fighters are required to work in the midst of and are subject to smoke, fumes, or carcinogenic, poisonous, toxic or chemical substances. Fire fighters are continually exposed to a vast and expanding field of hazardous substances through hazardous waste sites and the transportation of such substances.

Fire fighters are constantly entering uncontrolled environments to save lives and reduce property damage and are frequently not aware of the potential toxic and carcinogenic substances that they may be exposed to. Fire fighters, unlike other workers, are often exposed simultaneously to multiple carcinogens; that the rise in occupational cancer among fire fighters can be related to the rapid proliferation of thousands of toxic substances in our everyday environment; and that the onset of cancer in fire fighters can develop very slowly, usually manifesting themselves from 5 to 40 years after exposure to the cancer-causing agent.

During the last two decades, the rapid proliferation of plastic products entering the marketplace has added a new dimension and risk of exposure to toxic substances to fire fighting. The presence of plastics can be expected at nearly every fire emergency. This did not exist 25 years ago.

It is time that Wisconsin recognize the direct connection between cancer and fire fighting and enact legislation recognizing this fact. The PFFW is working to that end!

IAFF DEPARTMENT OF OCCUPATIONAL HEALTH AND SAFETY

SUMMARY OF THE VIEWS ON OCCUPATIONAL CANCER IN FIRE FIGHTERS

Thank you for requesting information on Occupational Cancer in Fire Fighters. This document will serve to summarize and interpret the contents of the informational packet enclosed, as well as briefly state the views of the IAFF Department of Occupational Health and Safety on this matter.

I. Summary of Cancer in Fire Fighters

(1) It has been documented in scientific studies that fire fighters are exposed to thousands of different chemical agents during the course of their duties. Many **industrial hygiene** studies performed in fire fighters have actually measured exposures at real and simulated fires.

(2) Some of these chemicals are known to be carcinogens (cancer-causing agents). Most of the studies that have suggested that certain chemicals can cause cancer have been performed in animals, but some human epidemiologic studies do exist.

(3) Some of the chemicals to which fire fighters are exposed have been documented in epidemiologic studies to increase the risk of cancer in working populations (such as workers manufacturing or applying the agent). These include **vinyl chloride, asbestos, benzene, and polycyclic aromatic hydrocarbons (tars)**. These have been shown to cause liver cancer, lung and lung lining cancer, leukemia, and skin and lung cancer, respectively. These studies have not been performed in fire fighters, however.

(4) Several **mortality studies** have been performed in fire fighters (some of the reports are enclosed in this packet). When combining these studies, it appears that fire fighters have an increased risk (or incidence) of several types of cancer, including cancer of the **brain, rectum and colon, skin, and leukemia**. Other cancers, such as bladder cancer, have been found to be elevated in some studies but there is a lack of consistency in the findings.

The position of the IAFF Department of Occupational Health and Safety is that there is an increased incidence of some specific cancers in fire fighters.

(5) The information in the preceding paragraph may seem alarming but should be tempered with some additional knowledge. First, brain cancer and leukemia are uncommon cancers and an increased incidence of an uncommon cancer still results in relatively few cases of cancer. Secondly, rectum and colon cancer and skin cancer can be **cured** if detected and treated **early**. Finally, fire fighting will not cause any of these cancers if certain precautions to prevent exposures on the job are taken (for example, conscientious use of SCBA). Job-related cancers, like all occupational diseases, can be **prevented**.

(6) An interesting type of cancer that is surprisingly missing from the above list is **lung cancer**. A logical question is: Why don't fire fighters, who are exposed to chemicals in fire smoke identical to the lung-cancer-causing chemicals in cigarette smoke (called polycyclic aromatic hydrocarbons, or PAHs), have an increased incidence of lung cancer? This is a difficult question to answer. Fire fighter mortality studies have not found a convincing increased risk of lung cancer. This may be due to problems with the design or conduct of the studies.

(7) The issue of increased cancer in fire fighters is not without controversy, however. Some scientists feel the data are not clear; this is because of lack of consistency in the studies in their conclusions and the use of different methods and definitions. There are many epidemiologic reasons for this lack of agreement, so the IAFF Department of Occupational Health and Safety concludes that the **body of the evidence** weighs in favor of an increased incidence of certain cancers in fire fighters.

II. Definitions of Some Common Terms in Cancer Epidemiologic Research

(1) **Healthy worker effect:** In mortality studies, the incidence rate of a certain cause of death is **compared** to the incidence rate in some general population (usually the entire U.S. population). As fire fighters are healthier as a whole than the U.S. population, with certainly much less heart and lung disease (as these conditions would preclude the person from becoming a fire fighter), when rates of death from some cause in fire fighters are compared to the general rates fire fighters look to have a much decreased risk of the cause of death. This apparent decreased risk may not have been found if the fire fighters had been compared to a working population with similar health requirements (such as police). The decrease is thus an **epidemiologic artifact** that has been called the healthy worker effect.

(2) **Incidence rate:** This is the number of cases of disease in a population divided by the number of persons in the population at risk for the disease in a specified period of time (usually a year). The passage of time is an important requirement here.

(3) **Mortality study:** In fire fighter mortality studies, the causes of death are counted up for the fire fighters (the **observed** number of deaths) then compared to the **expected** number of deaths in the fire fighters if they had the **same rate of death** as some comparison population (usually the general U.S. population). These studies are performed in **cohorts** of fire fighters, some defined population of fire fighters with the criteria for study specified in advance (such as a minimum number of years employed, a certain city, etc.).

(4) **PMR (proportionate mortality ratio):** This is one common measure of the effect of fire fighting (or other jobs or exposures) on the incidence of disease in a fire fighter mortality study. The PMR looks at all the deaths in the population of fire fighters and calculates the **percent** (or **proportion**) of deaths due to a specific cause (for example, 35% of deaths were due to heart disease). This percent is then divided by the percent of deaths due to a specific cause in a comparison population. **This ratio is the PMR.** It is usually then multiplied by 100 so that PMRs above 100 mean "increased risk" (for example, a PMR of 270 is interpreted to mean that fire fighters had 2.7 times the risk of a certain cause of death). In general, the PMR is not thought to be as good an estimate of the risk of death due to a job or exposure as the SMR. PMRs are subject to many potential problems which often make them less valid epidemiologic tools.

(5) **Polycyclic aromatic hydrocarbons (PAHs):** Polycyclic means "many rings" (the molecular structure is in a ring or circle shape); aromatic means "similar to **benzene** in molecular structure"; and hydrocarbons means that the molecule consists of the atoms hydrogen and carbon. These chemicals, also known as **tars**, are known human carcinogens.

(6) **Risk:** Risk is expressed as a number between 0 and 1 (and if multiplied by 100 gives **"percent"**). It is most relevant for fire fighters in the context of cancer when expressed as the lifetime risk of developing a certain kind of cancer (for example, over the lifetime of a typical fire fighter, there is a 14% risk or **chance** of cancer "X"). The risk of a certain cancer in fire fighters can be divided by the risk of the same cancer in a comparison population to give a ratio of risks. If this is above 1, then there is an increased risk of this cancer in fire fighters.

(7) SMR (standardized mortality ratio): When the **observed** number of deaths from a mortality study (see above) is divided by the **expected** number of deaths based on the death rates in a comparison population, this ratio is called an SMR. The term **"standardized"** usually means that the effects of age (because cancer is known to increase with age, if one population is older than the other it would have an increased number of cancer deaths for this reason) have been removed by adjusting or standardizing the ages of the two populations (the two populations are the fire fighters and the comparison population).

ANNE L. GOLDEN, PHD
STEVEN B. MARKOWITZ, MD
PHILIP J. LANDRIGAN, MD, MSC

THE RISK OF CANCER IN FIREFIGHTERS

From the Division of Environmental and Occupational Medicine
Department of Community Medicine
Mount Sinai School of Medicine
New York, New York

Reprint requests to:
Anne L. Golden, PhD
Assistant Professor
Box 1057
Mount Sinai School of Medicine
One Gustave L. Levy Place
New York, NY 10029

Cancer among firefighters has been an area of intensive investigation in occupational medicine for the past two decades. This research has been prompted by the recognition that firefighters are exposed in their work to high doses of multiple chemical carcinogens. The full extent of the occupational cancer risk of firefighters is not yet known. It is likely that in the years ahead, additional cancers will be found to be associated with exposures encountered by firefighters and that additional chemicals to which firefighters are already known to be exposed will be found to be carcinogenic. Despite the gaps in scientific knowledge, concern about excess cancer risk has resulted in the provision of disability benefits to firefighters under presumptive occupational cancer legislation in 15 states (Alabama, California, Illinois, Louisiana, Maryland, Massachusetts, Minnesota, Nevada, New Hampshire, North Dakota, Oklahoma, Rhode Island, Tennessee, Texas and Virginia) and in the city of New York.

A substantial body of literature now exists on the carcinogenic hazards of firefighting. Of particular concern are cancers that can be plausibly linked with specific toxic and carcinogenic chemical exposures to which firefighters are exposed in the course of their work: leukemia, lymphoma, multiple myeloma, melanoma, and cancers of the respiratory system, digestive system, genitourinary tract and brain.[30,36,45,64]

CARCINOGENIC EXPOSURES OF FIREFIGHTERS

Firefighters are routinely exposed to complex and dynamic mixtures of chemical substances that are contained in fire smoke and building debris.[14] Despite the large numbers of people employed in this occupation, the nature of these exposures is not well defined. Studies that have been completed to date, however, clearly demonstrate the presence of recognized and suspected human carcinogens in the breathing environment of firefighters at the fire scene.

The relative paucity of information about the exposures of firefighters is not surprising given the complexity of such exposures and the methods by which they are studied. Fires vary greatly in the nature of the materials burned, temperature, size, and ambient weather conditions.[14] The nature and concentrations of airborne exposures change at the fire scene over short distances and upon the stage of the fire. The actual exposures received by firefighters further depend on their job tasks at the fire and the type and use of respiratory protection. Finally, measurement of airborne exposures at fires presents formidable technical challenges in sampling methods, equipment, and logistics.[37]

While studies of firefighters have emphasized the importance of exposures at the fire scene, exposures at the firehouse, where firefighters spend long hours, also may have an impact on their risk of cancer. Diesel exhaust from fire trucks, especially if their engines are run in closed houses without direct venting to outside air, may lead to high levels of diesel exhaust emission particulates that are probably carcinogenic.[24] Many fire companies are located in old buildings, where deteriorating asbestos-containing insulation material may produce harmful levels of exposure to resident firefighters.

The following sections summarize the available data regarding carcinogenic exposures in the work environment of firefighters.

Benzene

Benzene is firmly established as a human carcinogen.[36] Numerous studies have shown that benzene is a common airborne contaminant in fire smoke and occurs in concentrations that are considered deleterious in the context of chronic exposures.

Treitman, Burgess, and Gold studied ambient environmental levels of a number of air contaminants, including benzene, at more than 200 structural fires in Boston in the mid-1970s.[69] Benzene was detected in 181 of 197 (92%) samples taken at fire scenes by air sampling units placed on the chests of firefighters. Half of the samples showed benzene over 1 part per million (ppm), the current OSHA permissible exposure level. Approximately 5% of the samples were above 10 ppm benzene.[69]

Lowry and colleagues studied firefighters' exposure to benzene at nearly 100 structural fires in Dallas in the early 1980s.[41] They found benzene at the majority of the fires but did not provide information about the levels measured. They also detected the presence of at least 70 organic chemical species regardless of whether synthetic materials were a major part of the materials burned.

Brandt-Rauf et al.[11] used personal portable sampling devices to measure exposures of 51 firefighters at 14 fires in Buffalo in 1986. The tubes of the sampling devices were attached to the firefighters' turnout gear, thereby representing ambient air outside the mask. Benzene was second only to carbon monoxide as the most common chemical substance detected at the fires.[11] It was detected in 18 of 26 samples from 12 of 14 fires. When detectable, the concentration of benzene ranged from 8.3 to 250 ppm. In only one sample where benzene was detected was its concentration below 10 ppm. Even when the smoke's intensity was rated as low, benzene was usually present in concentrations ranging from 22 to 54 ppm. The authors noted that respiratory protection was only partially used or not used at all at the fires judged to be of low smoke intensity.[11]

Jankovic and colleagues at the National Institute for Occupational Safety and Health (NIOSH) studied benzene and other exposures at 22 fires in the late 1980s, including 6 training fires, 15 residential fires, and 1 automobile fire.[37] Samples were collected via probes placed inside and outside the masks of working firefighters. In addition, industrial hygienists used a variety of sampling devices at the fire scene. Samples were taken separately during the two phases of a fire: knockdown and overhaul.

Half of the samples taken during the knockdown phase of the fire showed benzene in concentrations of 1–22 ppm. Of the 29 organic substances analyzed qualitatively by gas chromatography/mass spectrometry, benzene was the most common compound detected and was the only substance present in all eight samples.

To measure the efficacy of respiratory protection, samples for benzene were taken inside and outside the mask.[37] Surprisingly, the levels of benzene inside the mask were as high as those taken outside the mask and ranged from nondetectable to 21 ppm. The authors attributed this equivalence in benzene concentrations inside and outside the mask to partial or nonuse of the mask at the fire, especially after the initial phase of fire knockdown. They further suggested that benzene may be present only during the latter part of knockdown.[37]

During the overhaul phase of the fire, when respiratory protection is frequently removed, benzene concentrations were low, i.e., less than 1 ppm.[37]

Asbestos

Asbestos is universally recognized as a human carcinogen and has caused an excess in risk of a variety of cancers in numerous occupations.[36,63] The extent to which a firefighter has potential exposure to asbestos at the fire scene is an interesting and largely unanswered question. Since the building destruction caused by fires and the building demolition actively performed by firefighters during overhaul are likely to dislodge respirable asbestos fibers, the likelihood that firefighters have exposure to asbestos is high. However, the extent of such exposure is uncertain given intermittent exposure and use of respiratory protection.

Markowitz and colleagues at Mount Sinai School of Medicine in New York performed a cross-sectional study of 212 firefighters who had begun employment in the New York City Fire Department at least 25 years previously.[43] All participants had worked principally in ladder companies and, thus, had engaged in overhaul operations frequently. In addition, all participants had worked in locations in New York City where exposure to asbestos-containing materials was considered to be most common: high-rise office buildings, warehouses and factories, and poor neighborhoods with high fire activity in the 1960s.

Twenty of the 152 (13%) firefighters without prior exposure to asbestos had pleural thickening and/or parenchymal opacities on chest x-ray that represented characteristic sequelae of prior asbestos exposure. All of the chest-ray abnormalities were mild in degree. Twenty-two of the 60 (37%) firefighters with a history of exposure to asbestos prior to becoming a firefighter showed such radiologic abnormalities. Prevalence of radiographic abnormalities did not increase with duration of employment as a firefighter or duration from onset of employment, but the study criteria for subject selection assured a narrow range in these categories.

The authors concluded that long-term firefighters in urban areas may have significant exposure to asbestos and are at risk for asbestos-related diseases.[43] Although the Mount Sinai study was restricted to pleural and parenchymal fibrosis as outcomes of interest, the results are relevant to the issue of the risk of cancer for firefighters. The finding of excess risk of lung and pleural fibrosis due to asbestos among firefighters indicated that significant asbestos exposure has occurred in this group. Since significant asbestos exposure confers excess risk for selected cancers, it is reasonable to expect that firefighters have an increased risk of various cancers as a result of their exposure to asbestos.

No environmental study of ambient levels of asbestos at fire scenes has been undertaken. Jankovic et al. collected airborne fibers on cellulose filters at the scene of structural fires and analyzed these with polarized light microscopy.[37] The limit of detection was 0.4 fibers/ml. Fiber counts were higher during the overhaul phase than the knockdown phase of the fire. No asbestos fibers were detected, but cellulose and glass fibers were obtained. The investigators did not ascertain whether insulation materials were involved in any of the fires. They concluded that their results "do demonstrate the potential for exposures during overhaul when building materials contain asbestos."[37]

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a class of organic substances that have been implicated as the carcinogenic substances in coal tar pitches, coal tar, and selected mineral oils.[36] They have been associated with excess risk of a variety of cancers, including cancer of the skin, lung, kidney, and bladder.[36]

Given the combustion of diverse materials at fires, it is likely a priori that firefighters would be exposed to significant levels of PAHs. Earlier studies of airborne contaminants at fires concentrated on the measurement of acute irritants and asphyxiants, ignoring the presence of PAHs. In their recent study, Jankovic et al. evaluated the presence of PAHs at the scene of fires.[37] All 14 PAHs measured, including benz(a)pyrene, were present at mean values of 3–63 $\mu g/m^3$ during the knockdown phase of the fire. Concentrations of PAHs during overhaul were considerably lower than during knockdown and were similar to those seen in ambient air in the absence of fire.

Formaldehyde

Formaldehyde is considered a probable human carcinogen.[36] In animal experiments, formaldehyde has caused cancer of the nasopharynx and the sinuses. There is also limited evidence that formaldehyde may cause cancer at other organ sites.[1,8] The current OSHA permissible exposure level is 0.75 ppm for an 8-hour time-weighted average and 2 ppm for a 15-minute short-term exposure.

Formaldehyde has been measured at the fire scene by Lowry et al.,[41] Brandt-Rauf and colleagues,[11] and Jankovic et al.[37] Lowry et al. reported combined formaldehyde and acetaldehyde levels, with a mean of 5 ppm and a range of 1 to 15 ppm.[41] Brandt-Rauf and colleagues found aldehydes, including formaldehyde, at 4 of 14 fires at concentrations of 0.1 to 8.3 ppm.[11] Jankovic et al. detected formaldehyde at levels up to 8 ppm during knockdown and only 0.4 ppm during overhaul.[37] They also reported that airborne concentrations of formaldehyde inside the mask ranged from nondetectable to 0.3 ppm.

Diesel Exhaust

Considerable experimental and epidemiologic evidence gathered over the past 15 years suggests that constituents of diesel exhaust emissions are carcinogenic and may present a risk to occupations with regular exposure. Firefighters have significant potential for exposure to diesel exhaust, because fire trucks with diesel engines are routinely started inside of and backed into firehouses.

Froines and colleagues studied the concentration of diesel exhaust particulates in the air inside firehouses in New York, Boston, and Los Angeles in 1985.[24] Participating firefighters wore personal air samplers throughout the work shift while they were in the firehouse.

Unlike studies of air contaminants at the fire scene, the concentrations of airborne diesel particulate measured in this study should accurately reflect the actual exposure of firefighters to diesel emissions. Firefighters obviously do not wear respiratory protection at the firehouse. In addition, firefighters spend much of the work shift inside the firehouse, so that the 8-hour time-weighted average concentration reported by Froines et al. should meaningfully approximate the diesel exhaust exposure of urban firefighters on the job.[24]

Significant exposure to diesel exhaust particulates was detected.[24] Total airborne particulates from diesel exhaust emissions ranged from 170 to 480 $\mu g/m^3$. Worst case scenario sampling, during which a very active shift was simulated, detected levels of diesel exhaust particulates in the air of fire houses as high as 748 $\mu g/m^3$. The authors conclude that these levels of diesel exhaust emissions may be associated with a significant carcinogenic risk and efforts to reduce exposure should be made.[24] Unlike exposures received at the fire scene, diesel exhaust emissions emanate from a specific source that can be controlled with local ventilation attached to the exhaust pipe of the fire truck.

Other Agents

Although less well studied, there are additional environmental agents to which firefighters are exposed and for which experimental and/or epidemiologic studies support a relationship between exposure to the agent and the development of cancer. Examples include polychlorinated biphenyls (PCBs), various furans, styrene, and methylene chloride. In the studies by Jankovic et al.[37] and Lowry et al.[41] discussed above, the latter three agents or groups of agents were found in measurable concentrations at multiple fires, but data on actual airborne levels were not provided. Indeed, in the study by Lowery and colleagues, 70 organic agents were repeatedly identified in the smoke at multiple fires in Dallas.[41] Given the large number of chemicals that have been identified as being carcinogenic in the past two decades, at least in rodent test systems,[55] it is likely that fire smoke contains additional carcinogens beyond those identified to date.

Conclusion

In conclusion, empirical data are now sufficient to support the notion that firefighters are exposed to carcinogens in their work environment. The significance of such exposures is still unresolved. The exposures of firefighters are intermittent and variable in intensity. The respiratory protection they use is of uncertain efficacy and limited acceptability in the real world. Important exposures such as asbestos and diesel exhaust may occur during overhaul or at the firehouse, when respirators are not typically used. Furthermore, even if the dose of various carcinogens received by firefighters were better known, the residual uncertainty about the degree of risk imparted would be great. Although the fact that firefighters are exposed to carcinogens in their work environment has been established, much additional work remains to be done. Sufficient knowledge exists at present, however, to justify diligent efforts to reduce the exposure of firefighters to known carcinogenic agents.

PREVALENT CANCERS IN FIREFIGHTERS AND ASSOCIATIONS WITH CARCINOGENIC OCCUPATIONAL EXPOSURES

The results of 19 epidemiologic studies of cancer in firefighters published in the medical literature are summarized below. The data show that employment as a firefighter increases the risk of developing and dying from certain specific cancers: leukemia, nonHodgkin's lymphoma, multiple myeloma, and cancers of the brain, urinary bladder, and, possibly, prostate, large intestine, and skin. Graphic presentations of data related to these specific cancers (Fig. 1–6) include results from all published epidemiologic studies of firefighters that reported on that cancer. (Results for nonspecific organ systems or sites, e.g., digestive system or hematopoietic/lymphatic system, were not included.) For

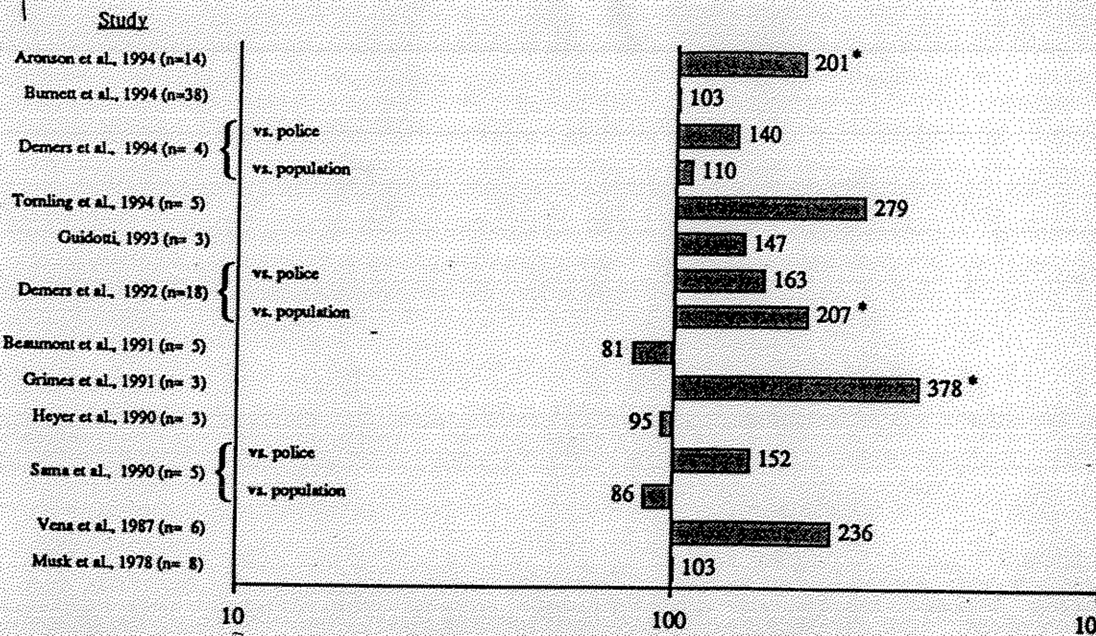


FIGURE 1. Brain cancer risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 on log^{10} scale. *Statistically significant increase in risk ratio ($p<0.05$).

a given study, the "risk ratio" reported is the measure the authors used to express the association between firefighting and cancer: a standardized mortality ratio (SMR), proportionate mortality ratio (PMR), standardized incidence ratio. (SIR), or a relative risk, incidence density ratio or odds ratio multiplied by 100 (RR). The number of cancer cases or deaths observed among firefighters, the risk ratio, and the statistical significance of the result are indicated for each study. Unless otherwise stated, the reference group used to calculate a risk ratio was the general population; certain studies calculated risk ratios for more than one reference group, for example, police officers and the general population.

Brain Cancer

Chemical exposures that are suspected causes of brain tumors include vinyl chloride, benzene, PAHs, PCBs, N-nitroso compounds, triazenes and hydrazines.[36,65,71] Recent epidemiologic studies consistently have found that brain cancer is strongly associated with firefighting, as shown in Figure 1. Generally, excess risk was most notable within 15–30 years of exposure, i.e., after a relatively short latency.[2,16,68,70] Howe and Burch[34] analyzed all cancer mortality studies of firefighters available as of 1989 and concluded that brain cancer fulfilled the criteria indicative of a causal association with firefighting, with a pooled SMR of 143 (95% confidence interval =93–212).

A study by Aronson et al.[2] of firefighters in metropolitan Toronto reported a statistically significant overall SMR of 201 (95% CI=110–337) for brain cancer, with the highest mortality among those with 5–9 years duration of employment as a firefighter (SMR=625, 95% CI=170–1,600). Demers et al.[16] analyzed mortality data from three northwestern cities in the United States and found that firefighters with 10–19 years of employment were at greatest risk (SMR=353, 95% CI=150–700). Although based on only three deaths, an analysis of Honolulu firefighters by Grimes et al.[28] found a PMR of 378 (95% CI=122–1,171) for brain and other central nervous system cancers; analyses by years of employment, were not reported. Tornling et al.[68] were unique in finding dose-response relationships between brain cancer incidence and increasing age, duration of employment, and years since hire, and between brain cancer mortality and increasing age, duration of employment, and estimated number of fires fought among Stockholm firefighters who worked during 1931–1983.

Cancers of Hematopoietic and Lymphatic Systems

Leukemia and lymphoma are associated with environmental and occupational exposure to benzene and 1,3-butadiene.[36,47,49,72] The prevalence of benzene as a solvent, as a component of gasoline, and as a combustion product that forms during the burning of plastics and synthetics, and of 1,3-butadiene, a monomer found in tires and synthetic rubber products, guarantees that firefighters will be exposed to the gases released by these materials as they burn. Chemical exposures that have been associated with multiple myeloma include benzene and petroleum products. Multiple myleoma risk is also increased in farmers, paper producers, furniture manufacturers, and woodworkers.[9]

LEUKEMIA

As seen in Figure 2, the majority of epidemiologic studies have found that firefighters are at increased risk of leukemia.[2,22,33,50,59] For example, Feuer and Rosenman[22] reported a statistically significant PMR of 276 for firefighters compared to police officers in New Jersey and an almost twofold increase in mortality compared to the general population in New Jersey and in the United States. Similarly, Sama et al.[59] found that firefighters had almost three times the risk of police officers when incident cases reported to the Massachusetts Cancer Registry from 1982 to 1986 were examined (age-standardized mortality odds ratio=267, 95% CI=62–1,154). Several studies found that the highest risk occurred at older ages, after at least 30 years latency or duration of employment.[2,16,33] However, a recent large study from NIOSH[12] combining mortality data from 27 states reported excess risk for firefighters younger than 65 (PMR=171, 95% CI=118–240).

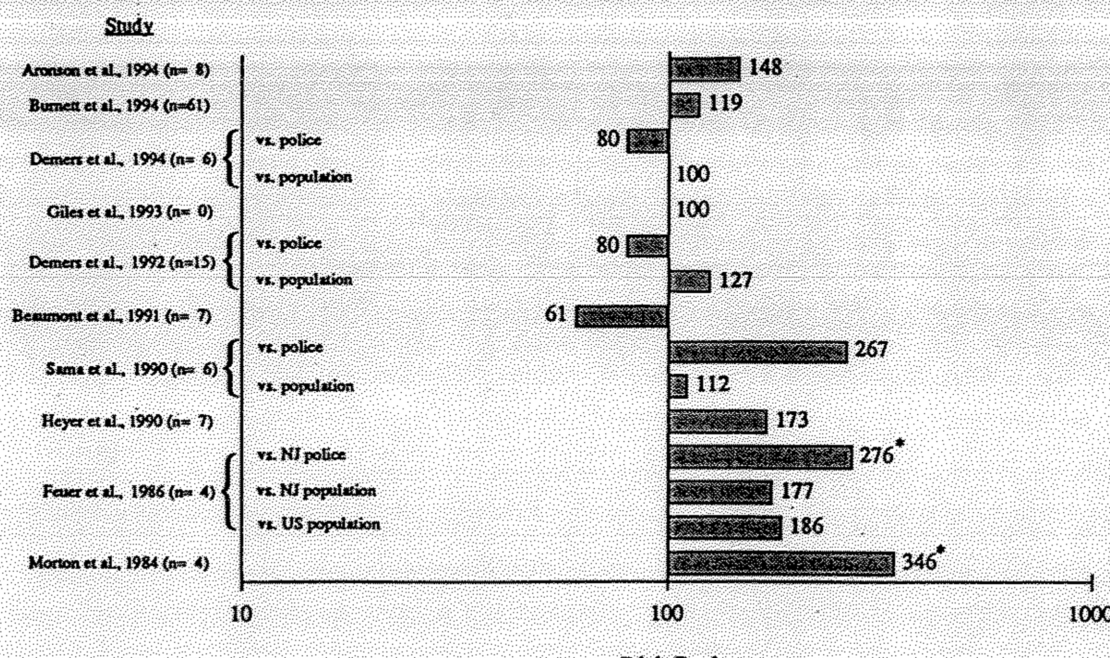


FIGURE 2. Leukemia risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 on log[10] scale. *Statistically significant increase in risk ratio (p<0.05).

NonHodgkin's Lymphoma

Several studies of firefighters evaluated this group of malignant diseases. Without exception, marked increases in risk were found (data not shown).[2,12,15,26,59] The study from the Massachusetts Cancer Registry by Sama et al. found a statistically significant SMOR of 327 (95% CI=119–898) for firefighters relative to police officers.[59] Studies by Giles et al.[26] from Melbourne, Australia, and Aronson et al.[2] from Toronto, Canada, reported that firefighters had twice the risk of non-Hodgkin's lymphoma of males in the general population.

Multiple Myeloma

Few individual epidemiologic studies of firefighters had sample sizes sufficient to assess risk of multiple myeloma (data not shown). Two of the four published studies that included multiple myeloma found lower than expected risk, based on one[2] or two[15] cases among firefighters. Two other studies reported increased risk associated with firefighting.[12,33] Although the confidence intervals were wide, the analysis of a cohort of Seattle firefighters by Heyer et al.[33] reported an overall SMR of 225 (95% CI=47–660) and, for men with 30 years or more of fire combat duty, a statistically significant SMR of 989 (95% CI=120–3,571). Using the mortality experience for 1984–1990 for firefighters from 27 states, Burnett et al. found a statistically significant age-adjusted PMR of 148 (95% CI=102–207).[12] Howe and Burch[34] combined the results of all cancer mortality studies of firefighters available as of 1989 (including four unpublished reports) and concluded that there was consistent evidence of a causal association between multiple myeloma and firefighting (pooled SMR=151, 95% CI=91–235).

Cancers of Genitourinary System

Bladder Cancer

Occupational chemical exposures known to cause bladder cancer include several aromatic amines, solvents, benzidine, PAHs, coal tars and pitches, soot and oils,[13,31,36] substances commonly encountered by firefighters, particularly at fires in commercial establishments. As seen in Figure 3, the majority of epidemiologic studies found that firefighting was associated with increased risk for bladder cancer. Guidotti[29] and Vena et al.[70] both reported a threefold increase in bladder cancer deaths compared to general population rates, with peak risks for firefighters age 60 and older, with latency of 40 or more years. Using incident cases from the Massachusetts Cancer Registry, Sama et al.[59] found a statistically significant increased risk for firefighters compared to police officers (SMOR=211, 95% CI=107–414) and to the general population (SMOR=159, 95% CI=102–250). Demers et al.[16] reported, based on two deaths, that the rate of bladder cancer was markedly lower than expected in a cohort of firefighters employed at least one year between 1944 and 1979 in Seattle and Tacoma, Washington, and Portland, Oregon (SMR=23, 95% CI=3–83 compared to the general population; age-standardized incidence density ratio =16, 95% CI=2–124 compared to police officers). However, in a recent retrospective cohort study among the firefighters from Seattle and Tacoma, the authors determined that cancer incidence was greater than expected relative to both the general population and the police, based on 18 incident bladder cancer cases among firefighters reported to a Surveillance, Epidemiology and End Results (SEER) tumor registry during 1974–1989.[15]

Kidney Cancer

Occupational exposures that have been implicated as risk factors for renal cell carcinoma include asbestos, PAHs, lead phosphate, dimethyl nitrosamine, coke oven emis-

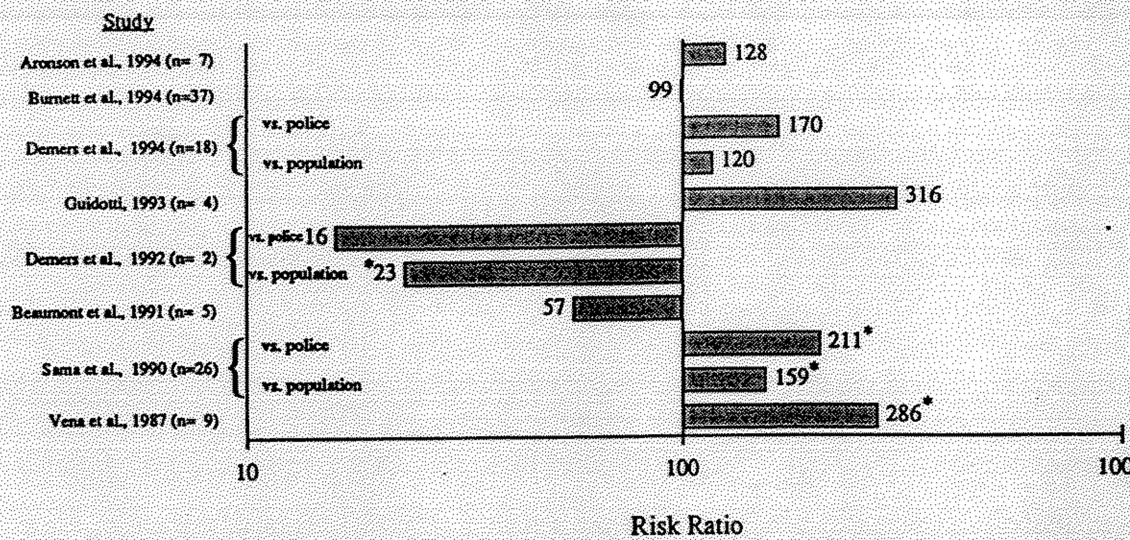


FIGURE 3. Bladder cancer risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 on $\log^{10}$ scale. *Statistically significant increase in risk ratio ($p<0.05$).

sions, and gasoline.[36,56,62] This list clearly includes agents encountered in firefighting; however, the eight epidemiologic studies that assessed kidney cancer in firefighters did not show consistently elevated risk (data not shown). Burnett et al.[12] and Guidotti[29] did find statistically significant excess mortality among firefighters from 27 states in the United States and from Alberta, Canada, respectively. Guidotti's SMR of 414 (95% CI=166–853) for kidney and ureter cancer was the highest SMR reported in the study. Risk was greatest after 40–49 years latency and increased with duration of employment as a firefighter and with a calculated index of firefighting exposure opportunity.[29] Conversely, a number of studies have reported lower than expected risk among firefighters.[2,6,15,16] Studies from the northwestern United States by Demers and others found lower than expected kidney cancer mortality[16] and incidence.[15] Although based on only two deaths, the SMR of 27 (95% CI=3–97) for kidney cancer mortality was statistically significant relative to the general population.[16]

PROSTATE CANCER

High rates of prostate cancer have been reported among workers with cadmium exposure and in chemists, farmers, loggers, textile workers, painters, and rubber industry workers.[20,27,38,48] While no obvious carcinogenic exposure is common to all these groups, occupational risk factors clearly should be considered along with endocrinologic, sexual, and dietary factors in the etiology of prostate cancer. Figure 4 summarizes the data on firefighters' risk for prostate cancer. A 30–50% increase in risk was consistently found in the majority of studies. Giles et al.[26] found that prostate cancer incidence among firefighters employed in Melbourne, Australia, between 1917 and 1989 occurred at twice the expected rate (SIR=209, 95% CI=67–488). A proportionate mortality study by Grimes et al.[28] from Honolulu found statistically significant increases for prostate cancer in both Caucasian (PMR=370, 95% CI=171–802) and Hawaiian (PMR=335, 95% CI=107–1,045) firefighters. On the other hand, Beaumont et al.[6] found a statistically significant decrement in prostate cancer mortality (SMR=38, 95% CI=16–75) in a retrospective cohort study of firefighters employed between 1940 and 1979 in San Francisco.

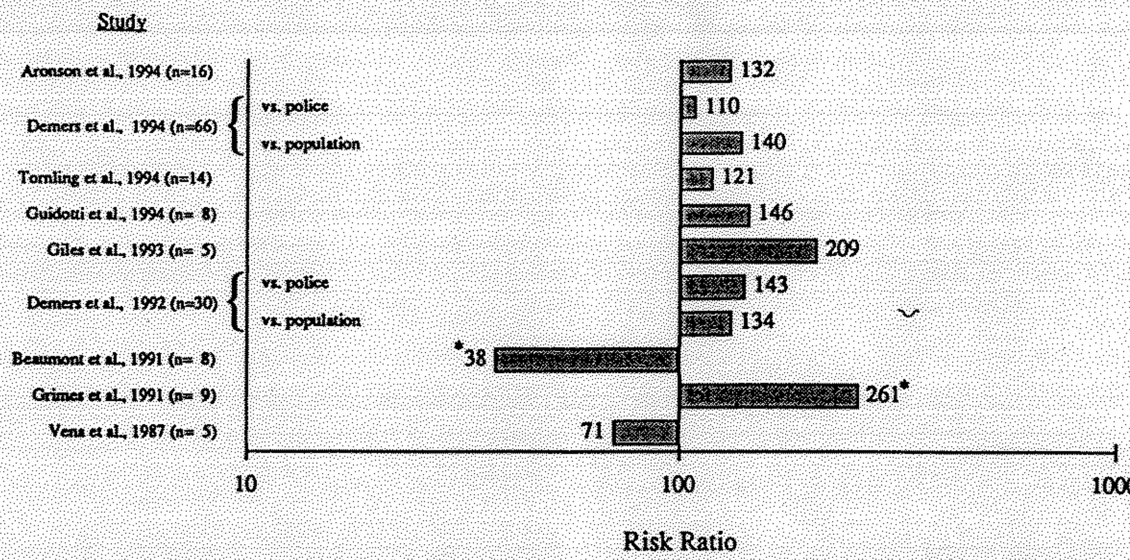


FIGURE 4. Prostate cancer risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 on log[10] scale. *Statistically significant increase in risk ratio ($p<0.05$).

Testicular Cancer

Only two epidemiologic studies specifically addressed testicular cancer in firefighters.[2,26] Giles et al.[26] found no association between testicular cancer incidence and employment as a firefighter in Melbourne, Australia, between 1917 and 1989; however, this study was restricted to cancers that occurred between 1980 and 1989, and only two cases were reported. A recent report by Aronson et al.[2] found higher than expected mortality for men employed by the Toronto Fire Department during 1950–1989. Over this 40–year period, three testicular cancer deaths occurred in the cohort when only 1.19 were expected based on the Toronto male population of the same age and calendar period, for an overall SMR of 252 (95% CI=52–737). All three deaths occurred in younger men with less than 15 years as firefighters (SMR=366, 95% CI=75–1,069) and within 20 years of first exposure (SMR=326, 95% CI=67–953). The epidemiologic characteristics of testicular cancer show that it occurs most commonly from age 20 to 34, with a white:black ratio of 4:1 and a positive correlation with socioeconomic status.[60] The incidence and mortality rates in men younger than 30 have been increasing over time. Although occupational risk factors have not been studied well, exposures to solvents and paints have been implicated.[23] Testicular cancer risk should be assessed in future studies of firefighters.

Cancers of the Digestive System

Several established occupational exposures increase the risk of cancer of the digestive system: asbestos, cutting and lubricating oils, dyes, solvents, and metallic compounds.[25,36] It is hypothesized that, once cleared from the airways, inhaled particles and the carcinogens that adhere to them are transferred to the gastrointestinal tract and swallowed and exert their effect on the digestive epithelium. Cancers of the rectum, colon, liver, pancreas, stomach, and esophagus were assessed in the majority of epidemiologic studies, but too few studies included cancers of the buccal cavity or pharynx for meaningful discussion.

LARGE INTESTINE

Of particular relevance to firefighters are the higher than expected rates of colon and rectal cancer observed in workers with exposure to asbestos.[63] Figure 5 demonstrates that excess rectal cancer has been found consistently in many studies of firefighters.[2,6,12,15,52,59,68,70] A similar pattern was evident for colon, colorectal or "intestinal" cancer,[7,15,16,18,26,30,52,70] although the risk ratios tended to be somewhat lower (data not shown).

An analysis by Burnett and colleagues[12] of mortality data for firefighters from 27 states found a statistically significant excess of rectal cancer, particularly under age 65 (PMR=186, 95% CI=110–294). Orris et al.[52] reported significantly higher mortality in Chicago firefighters during 1940–1988 for both rectal (PMR=164, 95% CI=114–230) and colon (PMR=131, 95% CI=104–165) cancers. In three other studies,[2,68,70] rectal cancer mortality among firefighters occurred at twice the expected rate, but these results did not reach statistical significance. Slightly lower than expected mortality was observed in two analyses of firefighters from the northwestern United States.[16,33] However, the latest study from this area found that rectal cancer incidence was similar to both the police and the general population, while colon cancer incidence, although not significantly elevated, appeared to increase with duration of employment as a firefighter.[15]

LIVER CANCER

Primary liver cancer is rare in the general population of the United States. Angiosarcoma of the liver has been associated with occupational and environmental exposures, including arsenic and vinyl chloride monomer from PVC.[21,36] PVC can be assumed to be present at every structural fire site in recent years involving furniture, electrical wire, and cable insulation and water pipes, and at automobile fires.

Five epidemiologic studies reporting results for cancer of the liver (including

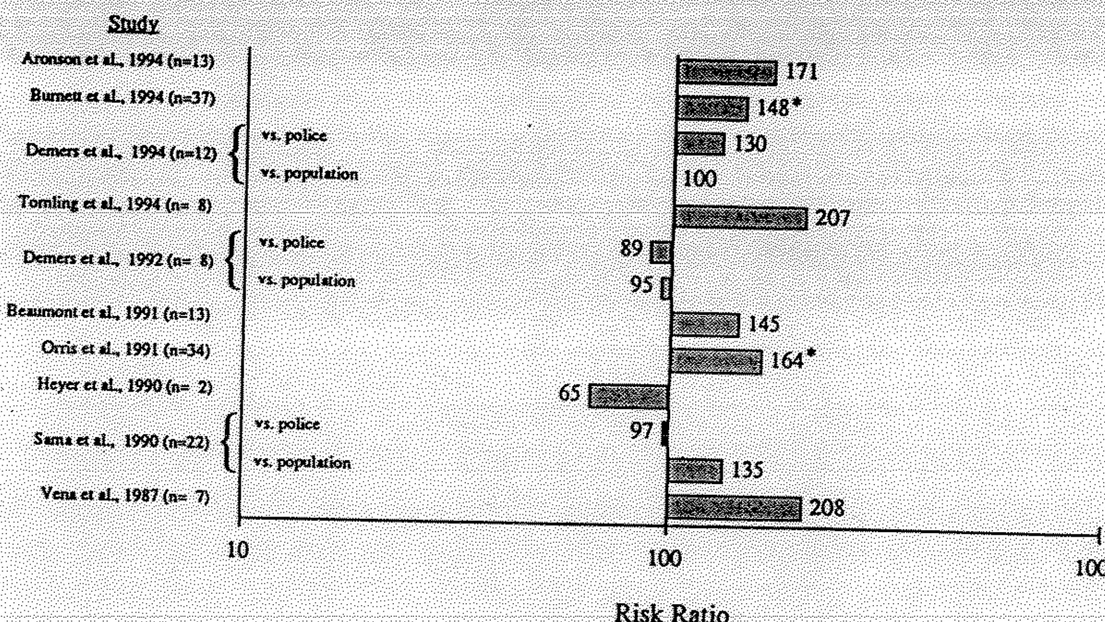


FIGURE 5. Rectal cancer risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 on log[10] scale. *Statistically significant increase in risk ratio ($p<0.05$).

cancer of the biliary passages and gallbladder) were all based on small numbers of cases observed in firefighters (data not shown). The study with the largest number[6] found a twofold excess for liver cancer mortality relative to the United States population among firefighters in San Francisco who were employed between 1940 and 1970 (SMR=191, 95% CI=87–363, n=9). Tornling et al.[68] found a nonsignificant increase in mortality (SMR=149, 95% CI=41–381, n=4) but a slight decrement in incidence (SMR=85, 95% CI=23–218, n=4) for liver cancer in Stockholm firefighters employed during 1931–1983, relative to regional rates. Three additional studies found no association between firefighting and liver cancer.[2,16,70] Although such an association is biologically plausible, only a very large study or meta-analysis would have adequate statistical power to detect an increase in this rare cancer.

Pancreatic Cancer

Many occupations and chemical carcinogens have been studied in relation to pancreatic cancer, with little consensus.[53] Workers in chemical, petroleum, and metallurgic industries may have particularly high risk from exposures such as benzidine, β-naphthylamine derivatives, and metal dusts.[40,53,54] In general, epidemiologic data suggest that firefighting is not associated with cancer of the pancreas (data not shown). One study found a large but nonsignificant increase in incidence for firefighters compared to police officers (SMOR=319) but not compared to the general population (SMOR=98) in Massachusetts.[59] Eight additional investigations assessed pancreatic cancer in firefighters: one study reported a nonsignificantly decreased risk (SMR=38),[26] three studies reported slightly elevated risk,[2,6,30] and four studies reported equal risk relative to the general population.[15,16,26,68]

Stomach and Esophageal Cancer

Adenocarcinoma of the stomach and cancer of the esophagus have been associated with asbestos exposure;[10,25,62] as discussed above, asbestos is prevalent at the majority of structural fires. Workers involved in rubber manufacturing, metal working, wood and paper working, and coal mining have also shown high rates of stomach cancer.[25]

Most of the epidemiologic studies that addressed stomach cancer found a positive association with firefighting,[6,15,16,18,33,68,70] but none of the overall results were statistically significant (data not shown). Eliopulos et al.[18] studied a cohort of firefighters employed during 1939–1978 by the Western Australia Fire Brigade. Mortality from stomach cancer was increased twofold relative to the general population (PMR=202, 95% CI=65–470). A study of firefighters employed in Stockholm during 1931–1983 found a small overall SMR of 121 for stomach cancer mortality;[68] however, both incidence and mortality increased with duration of employment and number of fires fought. Although tests for trend did not reach statistical significance, stomach cancer incidence was significantly elevated for firefighters with more than 30 years employment (SMR=289, 95% CI=149–505) or who fought more than 1,000 fires (SMR=264, 95% CI=136–461).

The data for cancer of the esophagus are more equivocal. Equal numbers of studies found positive[6,15,70] and negative[2,16,33] associations with firefighting (data not shown). Beaumont et al.[6] found that mortality from esophageal cancer occurred at twice the expected rate (SMR=204, 95% CI=105–357) in a retrospective cohort study of firefighters employed between 1940 and 1979 in San Francisco. No increase was demonstrated with increasing duration of employment or latency—in fact, the highest rate was seen for those with less than 20 years as a firefighter. The authors postulate that an interaction between smoke exposure and alcohol consumption could explain the pattern of cancer mortality in their study population: elevated rates for cancers of the liver, esophagus, buccal cavity, and pharynx.

Skin Cancer

Skin cancer is a heterogeneous group of diseases, the majority of which are malignant melanoma (30,000 new cases in the United States per year) or basal cell or squamous cell carcinomas (500,000 new cases per year). The most common risk factor for cancers of the skin is prolonged and intense exposure to sunlight. Occupational exposure to soot and tars, coke oven emissions, arsenic, and cutting oils also have been associated with increased risk.[19,36] Substances containing carcinogenic agents such as PAHs and PCBs may be absorbed by the skin of exposed body areas, including the hands, arms, face and neck, and other sites when protective clothing is permeated. Contact with these substances can occur during fire knockdown and overhaul and during the cleaning of clothing or equipment.

Figure 6 summarizes the studies that addressed skin cancer risk. (In studies that failed to differentiate melanoma from non-melanoma skin cancer, mortality rates are likely to include only melanoma since other forms of skin cancer are rarely fatal.) Several studies found that firefighters had a statistically significant excess risk of skin cancer compared to the general population.[12,22,59] Using deaths reported to a retirement system between 1974 and 1980, Feuer and Rosenman[22] found an almost threefold increase in skin cancer mortality for New Jersey firefighters compared to the United States population (PMR=270, $p<0.05$); firefighters were at somewhat higher risk than the general New Jersey population (PMR=190) but at the same risk as New Jersey police officers (PMR=135). Risk among firefighters clearly increased with duration of employment and interval since first employment (PMR=388 for more than 25 years duration; PMR=314 for more than 27 years latency); it was not clear which referent population was used for these comparisons. Sama et al.[59] analyzed incident melanoma cases reported during 1982–1986 to the Massachusetts Cancer Registry. They found a statistically significant excess for firefighters in comparison to the state population (SMOR=292, 95% CI=170–503) but no excess in comparison to police officers except in the age group 55–74 years (SMOR=513, 95% CI=150–1,750). Howe and Burch[34]

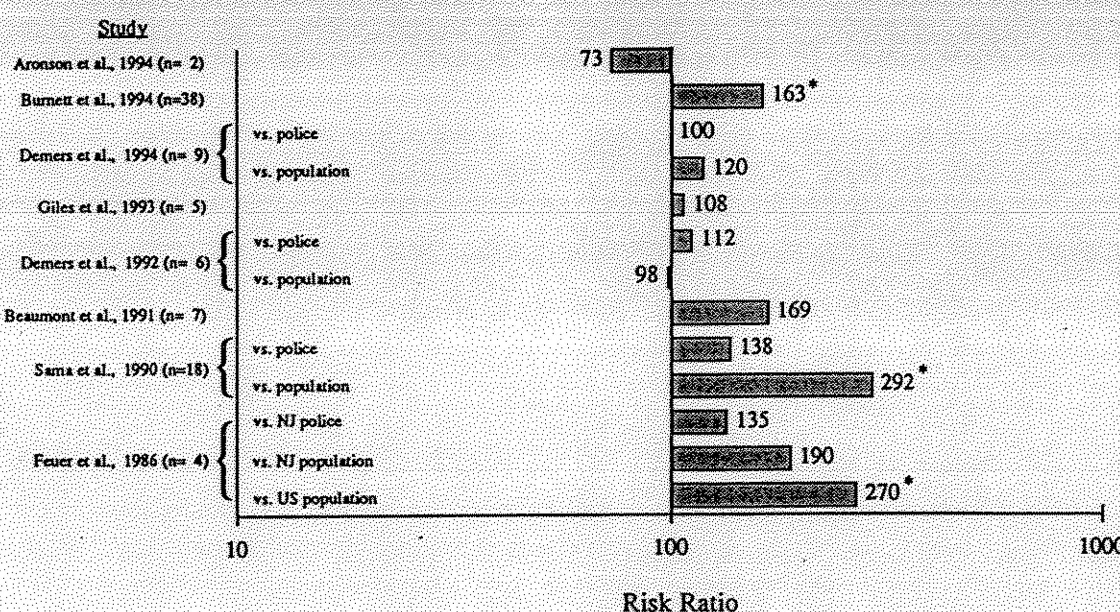


FIGURE 6. Skin cancer risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 on log[10] scale. *Statistically significant increase in risk ratio ($p<0.05$).

combined the results of the studies of cancer in firefighters published through 1989 and determined that there was evidence of a statistically significant increase in risk of melanoma (pooled SMR=173, 95% CI=103–274). However, they concluded that several criteria used to define a causal association were not fulfilled—for example, the ability to rule out potential confounders such as sunlight exposure and the limited evidence of a dose-response relationship.

Lung Cancer

As discussed above, firefighters may be routinely exposed to many known or suspected lung carcinogens, including asbestos, arsenic, PAHs, vinyl chloride and formaldehyde.[58] Inhalation exposure can occur during active fire combat as well as during the overhaul phase when protective breathing equipment is usually removed.

Accordingly, lung cancer was specified a priori in the majority of epidemiologic studies as an outcome that would be plausibly related to firefighting. Of the 16 published studies that addressed cancer of the respiratory tract, not one found a statistically significant excess risk of lung cancer for firefighters (data not shown). Only two cohort studies[29,32] found moderately increased risks: Guidotti from Canada, with an SMR of 142 (95% CI=91–211) for deaths occurring during 1927–1987, and Hansen et al. from Denmark, with an SMR of 163 for deaths occurring during 1970–1980 (95% CI=75–310). A case-control study using Missouri Cancer Registry cases diagnosed between 1980 and 1985 found the category that included police, firefighters, and protective service occupations had elevated risks for squamous-cell carcinoma, small-cell carcinoma, and other or mixed cell types, but not for adenocarcinoma of the lung.[73] These elevated risks were limited to current smokers only.

Discussion

These epidemiologic studies clearly demonstrate increased risk of several cancers that can be plausibly linked with carcinogenic exposures encountered by firefighters in their work. The data most strongly suggest that firefighters are at increased risk of developing and dying from leukemia, nonHodgkin's lymphoma, multiple myeloma, and cancers of the brain and bladder. The majority of studies that examined these cancers found markedly elevated risks for firefighters, and there are no viable alternative hypotheses or strong confounders that could readily explain their increased prevalence. Furthermore, exposure assessment studies have detected substances in the firefighting environment that are known or suspected causes of these cancers. Weaker but still plausible evidence links firefighting to increased risk of rectal, colon, stomach, and prostate cancers and melanoma.

The limitations of the epidemiologic data must be acknowledged. Most of the studies examined relatively small populations of firefighters and thus have low statistical power to analyze rare tumors. To increase their sample size, many of the studies analyzed deaths occurring over several decades; this technique introduces problems related to (a) trends in diagnoses, (b) differences in exposure over time, since many potential carcinogens, such as chemicals and synthetic materials, were introduced at different times during the relevant exposure periods, and (c) changes in protective equipment and awareness of hazards. Limited documentation of exposure is also a problem. Some studies relied on occupation as recorded on a death certificate or tumor registry, which may reflect the current or most recent job instead of the usual occupation. Recent studies have examined risk in relation to duration of active fire combat duty, latency (years since hire), age at diagnosis (active duty versus retirement), and number of fires fought. However, none were able to rank firefighters according to a cumulative index incorporating intensity of exposure. As a result, heavily exposed firefighters are comingled with lightly exposed firefighters, and the risks to the heavily exposed firefighters are diluted out and underestimated by the design of the studies.

None of the epidemiologic studies were able to take into account potential confounding variables other than age that could explain the observed associations between firefighting and cancer.[42] It is unlikely, however, that increased mortality rates among firefighters can be attributed solely to the personal lifestyle factors—diet, alcohol intake, cigarette smoking—that have been linked with certain cancers. The vast majority of studies found no excess risk of lung cancer, suggesting that firefighters are not more likely to smoke than the general population or other protective service workers. In fact, surveys have found that the proportion of firefighters who smoke is similar to the proportion of other service and blue collar workers who smoke.[5,59,67] In studies of occupation and cancer that did collect information on lifestyle factors, most associations remained unchanged after controlling for cigarette smoking,[4,17] and biased attribution of cause of death among smokers compared to nonsmokers has been shown to overestimate associations between smoking and cancer.[66]

The latency period for most of the relevant cancers associated with exposure to chemical carcinogens is likely to be at least three or four decades. Therefore, studies to date have not had sufficient follow-up time to detect the full extent of occupational cancer in the firefighters at greatest risk—those who were increasingly exposed to chemical carcinogens throughout the 1940s, 1950s, and 1960s without the benefit of modern protective equipment or awareness of hazards.

The results of the studies also may be subject to the paradox of the healthy worker and survivor effects.[3,35,46] Healthy individuals are more likely than unhealthy persons to seek and gain employment and to remain in their jobs. This effect is amplified by the stringent initial screening process and good employment benefits associated with employment as a firefighter, as evidenced by their low all-cause mortality rates. Although the healthy worker effect has less impact on cancer than on other causes of death, the higher than expected rates of cancer mortality among firefighters in comparison to the general population and, in particular, to other workers are unsettling. Indeed, the shortcomings of the epidemiologic studies are more likely to dilute or mask associations between occupational exposures of firefighting and cancer than to create falsely positive associations.

Few of the results presented reached statistical significance, and the confidence intervals around the risk ratios were generally wide. Statistical significance is determined by the magnitude of the exposure-disease association, the accuracy or variability of the exposure and outcome measurements, and the size of the study population. Therefore, the small numbers of cancers observed in individual studies contribute to instability in the risk estimates. Future studies that are able to include not just deaths but all incident cancers from large cohorts will benefit from analyzing greater numbers of events. Figures 1–6 illustrate the preponderance of evidence implicating certain specific cancers associated with firefighting. Although these cancers warrant particular attention, future investigations should continue to cast a wide net that includes all relevant cancers. The downside of testing many outcomes in relation to a number of exposure variables is that some associations may appear to be statistically significant by chance alone.

Because most of the epidemiologic studies used the retrospective cohort study design, investigators had access to employer records regarding employment period, work assignments, and vital status, rather than just occupation as recorded on a death certificate. Attempts should be made in future studies, particularly those with prospective components, to develop measures of acute and cumulative exposures on an individual basis, although potential misclassification will always be a concern given the nature of the firefighting environment. The techniques of molecular biology increasingly are being used to develop biomarkers of exposure in occupational and environmental settings.

For example, Liou et al.[39] monitored two biomarkers in firefighters: sister chromatid exchange (SCE), a general indicator of genetic damage resulting from exposure to mutagens and carcinogens, and polycyclic aromatic hydrocarbon (PAH)-DNA adducts, which are thought to measure the initiation of carcinogenic changes associated with exposure to PAHs. After controlling for charcoal-broiled food consumption, cigarette smoking and race, firefighters had a statistically significant fourfold higher risk of detectable PAH-DNA adduct levels compared to unexposed controls. This association may be specific to urban, structural firefighting; a similar study in wildland firefighters in California found no association between forest fire activity and PAH-DNA adducts.[57] The incorporation of biologic markers of exposure, cancer susceptibility, and preclinical effects should be considered in future epidemiologic studies of firefighters.

Despite the limitations cited above, the available exposure assessment and epidemiologic studies present convincing and consistent evidence that the toxic exposures encountered in firefighting may increase the risk for certain specific cancers. The relatively high incidence rates with which some of these cancers occur (prostate, colon, rectum) and, for rarer cancers, the particularly strong association with firefighting or dismal survival probability (brain, multiple myleoma) underscore the importance of understanding and reducing the cancer risks attributable to firefighting.

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STATE OF WISCONSIN
DEPARTMENT OF EMPLOYE TRUST FUNDS
801 West Badger Road
Madison, WI 53713

CORRESPONDENCE MEMORANDUM

DATE: September 17, 1997

TO: Honorable Rick Grobschmidt, Co-chair
Honorable Judith Klusman, Co-chair
Joint Survey Committee on Retirement Systems

FROM: Sandy Drew, Director SD
Legislation and Planning

SUBJECT: Cancer Presumption Costing

Per your request, Tom Korpady asked James Scearcy, the actuary for the Group Insurance Board, to cost out the effect that cancer presumption would have on the section 40.65 duty disability program. I have enclosed a copy of Mr. Scearcy's report. If you have questions about the report, please contact Tom Korpady (6-0207) or myself (7-2929).

SD:s
Enclosure
cc: Eric Stanchfield
Dave Mills
Tom Korpady
Blair Testin

Deloitte & Touche LLP

400 One Financial Plaza
120 South Sixth Street
Minneapolis, Minnesota 55402-1844

Telephone: (612) 397-4000
Facsimile: (612) 397-4450

August 29, 1997

Mr. Thomas C. Korpady
Director, Health and Disability Benefits
State of Wisconsin
801 West Badger Road
Madison, Wisconsin 53702

Re: Cancer Presumption Costing

Dear Tom:

Enclosed are the results of the Cancer Presumption Costing for the Section 40.65 Duty Disability Program. These figures represent the effect on plan contribution rates of amortizing the cost of this benefit over 14 years, which is the expected future working lifetime of the covered group. The resulting increases in premium rates were 1% if applied to the entire group covered under the Duty Disability Program or 7% if applied only to the municipal firefighter covered group. These increases would be applied evenly across the current rate schedule.

If you have any questions, please call Jim Scearcy at (612) 397-4038 or Gil Mathis at (612) 397-4071.

Sincerely,

James H. Scearcy, FSA, MAAA

Gil Mathis

JHS/psb
82702

Assumptions

- **Types of Cancer Covered:** All sites excluding heart and respiratory systems.

- **Eligibility for Benefit:** 10 years of service as a municipal firefighter and under age 53.

- **Cancer Incidence Rates:** SEER Cancer Statistics Review (National Cancer Institute), 1973-1991; 60% of the age-specific rates for white males (see attached).

- **Mortality Prior to Cancer Incidence:** Wisconsin Projected Experience Table - 93; male.

- **Withdrawal:** Termination rates used in the 12/31/96 Actuarial Pension Valuation.

- **Disability Incidence Rates (Other than Cancer):** Disability rates used in the 12/31/96 Actuarial Pension Valuation.

- **Interest:** (Which approximates an 8% valuation rate with 3% annual benefit increases).

- **Survival Rates after Diagnosis:** SEER Cancer Statistics Review, 1973-1991; 75% of the relative survival rates for males (see attached).

- **Funding Assumptions:** Cost is amortized over 14 years at 3% which approximates the real rate of return in excess of covered payroll growth.

Tables

Attained Age	Incidence Rates/100,000	Duration Since Diagnosis	Survival Rates as a %
27	35.5	1	60.23%
28	39.1	2	53.25
29	42.5	3	48.83
30	46.1	4	46.28
31	49.6	5	43.05
32	53.1	6	41.10
33	56.6	7	38.85
34	60.0	8	37.20
35	63.5	9	35.55
36	66.9	10	35.18
37	70.4	11	33.23
38	73.4	12	31.88
39	76.5	13	30.68
40	79.6	14	30.38
41	82.6	15	29.03
42	85.7	16	27.68
43	94.0	17	26.63
44	102.2	18	24.60
45	110.5	19	22.58
46	118.8	20	20.55
47	127.1	21	18.53
48	144.8	22	16.50
49	162.4	23	14.48
50	180.1	24	12.45
51	197.8	25	10.43
52	215.5	26	8.40
53	249.3	27	6.38
		28	4.35
		29	2.33
		30	0.30
		31	0.00

State of Wisconsin - DETF
Sec. 40.65 Duty Disability program
LRB 1538 Cancer Presumption Costing

Attained Age	Service				Payroll	Cost (PV)
	2	7	10	Total		
22	43	0	0	43	$ 909,243	$ 64,221
27	201	71	0	272	9,346,249	430,441
32	142	213	56	411	16,731,790	665,750
37	57	164	286	507	22,210,070	827,157
42	20	83	408	511	23,551,380	737,685
47	3	20	399	422	20,088,659	445,402
52	1	3	245	249	12,388,063	57,871
53+	3	2	205	210	10,440,572	0
Total	470	556	1599	2625	$ 115,666,026	$ 3,228,526

Effect on contribution rates

Entire Group	Present*	Proposed*	Increase in Contribution Rates
Current provision for annual incurred claims	2.33%	2.33%	
Current amortization of accrued shortfall	1.33%	1.33%	
Amortization of cost over EFWL**	-	0.04%	
Total	3.66%	3.70%	1%

Covered Group Only	Present*	Proposed*	Increase in Contribution Rates
Provision for annual incurred claims	2.33%	2.33%	
Amortization of accrued shortfall	1.33%	1.33%	
Amortization of cost over EFWL**	-	0.24%	
Total	3.66%	3.90%	7%

*% of covered payroll as developed on page five of the December 31, 1996 Actuarial Review
**The Expected Future Working Lifetime (EFWL) for this group is estimated to be 14 years.