STATE OF WISCONSIN

APPENDIX TO 1997 SENATE BILL 329

REPORT OF JOINT SURVEY COMMITTEE ON RETIREMENT SYSTEMS

(Introduced by Senators Wirch, Rude, Rosenzweig, Wineke, Chvala, Clausing, Burke, Roessler, C. Potter, Risser, Darling, Decker, George, Jauch, Panzer, Plache, Ellis, Moen, Shibilski, Breske and Farrow; cosponsored by Representatives Klusman, Walker, Musser, Krusick, Kreibich, Porter, Handrick, Schneider, Dobyns, R. Potter, Travis, Green, Ryba, Kreuser, Robson, Duff, Steinbrink, Johnsrud, Kedzie, Ladwig, L. Young, Sykora, Lorge, LaFave, Huebsch, Baumgart, J. Lehman, M. Lehman, Harsdorf, Otte, Boyle, Plale, Gunderson, Kaufert, Seratti, Gronemus, Hasenohrl, Underheim, Staskunas, Lazich, Goetsch, Rutkowski, Ott and Plouff.) 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.

EXTRACT OF COMMITTEE'S RECOMMENDATION ON THIS BILL

The Joint Survey Committee on Retirement Systems finds that Senate Bill 329 reflects good public policy, and the Committee recommends its passage.

PURPOSE OF THE BILL

Current law presumes that firefighters who develop heart or respiratory disease subsequent to their employment as firefighters, and after five years of service, have developed the disease as a consequence of their employment, and are therefore eligible for disability and death benefits under Wis. Stats. 40.65. S.B. 329 would provide similar presumption of occupational disability and eligibility under Sec. 40.65 to firefighters with 10 years of service who contract cancer of a type other than that already covered under the existing heart and lung provisions of state law. Unlike other Sec. 40.65 disabilities, they would need 10, rather than 5, years of service to be eligible, and they would not be allowed to withdraw the member's accumulated WRS contributions in addition to drawing an annuity under Sec. 40.65.

ACTUARIAL EFFECT

This bill would have no material actuarial effect on the WRS.

PROBABLE COST

James Scearcy, actuary for the Group Insurance Board, has estimated the cost of this bill to be about 0.24% of the payroll for covered firefighters. Estimating that payroll to be $131.7 million in 1999 implies an estimated cost to employers of $316,000 for that year. The cost should remain at about 0.24% of firefighters' payroll for a period of 14 years, and then decrease to about 0.14% of payroll, which will be the equivalent of $190,000 annually measured in current dollars. (This is because the actuary contemplated a 14-year payoff of the initial unfunded liability to the s. 40.65 program that would arise under this legislation.) This cost would be borne by the employers, and there would be no cost to the state.

PUBLIC POLICY

To date, 17 states have adopted cancer presumption laws for firefighters. Of Wisconsin's near neighbors, this includes Minnesota and Illinois.

Research on the exposure of firefighters to carcinogenic agents in the course of their duties has found damaging levels of numerous known and suspected carcinogens present at fires and in firehouses as well. Chief among these are benzene and other aromatic hydrocarbons, asbestos, formaldehyde, chemicals present in diesel exhaust, PCB's, styrene, methylene chloride, and other organic chemicals. One 1995 review of 19 epidemiologic studies of cancer in firefighters concludes that "The data show that employment as a firefighter increases the risk of developing and dying from certain specific cancers: leukemia, nonHodgkins lymphoma, multiple myeloma, and cancers of the brain, urinary bladder, and, possibly, prostate, large intestine, and skin." ("The Risk of Cancer in Firefighters", Occupational Medicine, vol. 10, no. 4, Oct - Dec 1995.)

Face masks and protective clothing are often inadequate protection for a firefighter, as notably in situations where their use interferes with doing the job (e.g., fogged face masks), and they are not used. Many harmful chemicals absorb through the skin as well as by inhalation, so that it may be impossible for a firefighter to avoid receiving harmful doses of carcinogens. In fact, diesel exhaust from firetrucks present in the air at firehouses has been determined to be a major cause of increased cancer risk for firefighters.

Based on those studies surveyed in the research paper already cited, for which statistical significance was found in the data to support the conclusion of increased cancer risk for firefighters, estimates were made for six types of cancer to answer this question: "What percentages of the cancers occurring in the sampled firefighters would not have occurred if they were not firefighters?" Here are the results:

Type of Cancer	Percentage of Cancers Estimated To Be Due to Additional Occupational Risk of Cancer
Brain cancer	54%
Leukemia	68%
Bladder cancer	54%
Prostate cancer	62%
Rectal cancer	36%
Skin cancer	59%

Under present Wisconsin law, a firefighter contracting cancer is not presumed to be occupationally disabled, so will typically continue to work until he/she is no longer able to, and then take disability retirement under Sec. 40.63 (nonoccupational disability). Social Security disability benefits are, of course, not available to firefighters in our state.

During the past 20 years, 26 Wisconsin firefighters with at least 10 years of service have developed cancer of a type covered under this bill (e.g., not lung cancer). Of these 26, only 16 were under age 53 and thus would have been eligible for disability benefits if S.B. 329 had then been law. Their average age when leaving service was 47 years, and their average length of service was 21 years. Ten of the 16 died within one year of leaving their jobs.

In light of this, the following table of six hypothetical cases seems fairly illustrative of the benefits now available to Wisconsin firefighters under Sec. 40.63 of statute. For each of these six firefighters it is assumed that.....

- Termination from service occurs in 1999.
- Final average earnings at termination from service is $45,000, and salary history has been typical.
- The firefighter is male, with a wife 4 years younger.

- The firefighter elects a 100% Joint and Survivor annuity (with no certain period) to give his wife the largest possible widow's pension.
- Death occurs one year after the disability annuity commences.

Note that $45,000 is close to the actual average salary for the 2,600 firefighters now in WRS. To consider salary levels other than $45,000, simply scale the annuity amounts shown here in proportion to a salary of $45,000.

Illustrative s. 40.63 Annuities to Firefighters with Cancer
(Final Average Earnings = $45,000 in each case.)

Age Hired	Age Disabled	Credited Service	Annual Annuity Paid	
			First Year	To Surviving Wife**
24	29	5*	$33,555	$ 1,589
24	39	15	32,961	5,735
24	49	25	29,891	20,621
34	39	5*	22,270	1,668
34	44	10	21,448	7,713
34	49	15	20,833	11,477

* Included for comparison only. 5 years of service does not qualify under this bill.
** Includes one year's dividend based on expected (8%) fund rate of return.

RECOMMENDATION

The Joint Survey Committee on Retirement Systems finds that Senate Bill 329 reflects good public policy, and the Committee recommends its passage.

3/10/98

Testimony
to the
Assembly Government Operations Committee
on SB 329, the Cancer Presumption Bill
by
Edward J. Huck
executive director
Wisconsin Alliance of Cities
March 17, 1998

Mr. Chairman, honorable members of the committee. Thank you for giving me the opportunity to explain the Alliance's views on SB 329, the so-called Cancer Presumption Bill.

Let me preface my remarks by emphasizing that I and the 32 city leaders for whom I work understand what an emotionally, and often financially devastating, experience cancer is for any family. Almost all of us have experienced what cancer can do to a loved one. I know I have.

We also support as high a level of salary and benefits as our taxpayers can afford for the firefighters in our communities, commensurate with their skills and professionalism.

But we do not support SB 329. We believe benefits for firefighters should be no different than for other groups of skilled, professional employees who perform dangerous work for their communities — unless there is a scientific basis for differential treatment.

And we do not believe representatives of the firefighters' unions who have pushed for SB 329 have offered any conclusive proof that the death and disability benefits provided to firefighters under SB 329 are justified. We have reviewed studies of cancer in firefighters, and offer to you the conclusions of the scientists who performed those studies — scientists who were not paid by the firefighter's union to attend a hearing in Madison.

Those scientists overwhelmingly find that overall, the cancer death rate among firefighters is lower or no different from the general population, a phenomenon known generally as a "healthy worker" effect. They willingly acknowledge that their studies do not take into account such relevant risk factors as prior military service, diet, tobacco use or alcohol consumption. And they freely admit that studies exploring a genetic association with cancer among firefighters are virtually unheard of.

A comprehensive new benefit for firefighters — and other local employees — is properly a subject for collective bargaining.

We began the 1998-1998 legislative session by asking the Assembly and Senate to institute comprehensive reform in the duty disability law along the lines suggested by the Legislative Audit Bureau in an August, 1996 report. Auditors found a series of abuses in the program. For example, one firefighter is receiving duty disability payments after falling off a ladder — while hanging Christmas tree ornaments at home.

SB 329 also would provide benefits for injuries that aren't job related. This isn't what we had in mind when we requested duty disability reform.

Thank you.

Behind the Testimony
on SB 329
The Cancer Presumption Bill*

Testimony by Dr. John Norton for the Int'l. Assn. of Fire Fighters:	What the researchers really said:
"Howe and Burch...concluded that there was **consistent evidence of a causal association** between multiple myeloma and firefighting."	"Overall, **the conclusion must be very tentative** because of limited numbers, but **there appears to be some evidence of a positive association** for multiple myeloma." [1]
"Feuer and Rosenman reported a statistically significant (cancer) risk of 2.7 times 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."	**"Overall, neither group** (police officers or fire fighters) **differed from the New Jersey male population in the cause of death.** Analyses by latency showed an increase in skin cancer and cirrhosis in firefighters and cirrhosis in police."[2]
"Recent epidemiological studies consistently have found that **brain cancer is strongly associated with firefighting."**	**"Cancer of the brain and central nervous system has shown highly variable findings** in the extant literature, but this is not surprising inasmuch as the numbers of cases in all reports are relatively small."[3]
"A recent report by Aronson et al. found **higher than expected (testicular cancer) mortality** for men employed by the Toronto Fire Department during 1950-1989."	"Elevated, although **not statistically significant,** risks ... are also apparent for several additional cancer sites: pharynx, rectum ... prostate, **testis,** lymphosarcoma, and lymphatic leukemia."[4]

*Prepared by the **Wisconsin Alliance of Cities**, March, 1998.

[1] Geoffrey R. Howe & J. David Burch, AMERICAN JOURNAL OF EPIDEMIOLOGY, Vol. 132, No. 6, December 1990.
[2] E. Feuer, K. Rosenman, AMERICAN JOURNAL OF INDUSTRIAL MEDICINE, Vol. 9, p 517-527.
[3] Tee L. Guidotti, AMERICAN JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL MEDICINE, Vol. 10, No. 4, December, 1995.
[4] Kristan J. Aronson et al., AMERICAN JOURNAL OF INDUSTRIAL MEDICINE, Vol. 26, p 92. (1994)

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SUMMARY OF SCIENTIFIC STUDIES ON CANCER RISK AMONG FIRE FIGHTERS

Overall Cancer Risk:

"Fire fighters are exposed to heavy smoke, poisonous gases and carcinogens every day, but **data linking cancer as an occupational risk of fire fighting have been conflicting at best,**" the *Journal of the National Cancer Institute* reported in July, 1991. [1]

The publication was commenting on three studies:

- Researchers at the National Cancer Institute of Canada reported in December, 1990, **a lower than expected lung cancer death rate and the same risk of colon cancer as among the general population**, based on studies of firefighters in Boston, the Pacific Northwest, Canada and western Australia. (emphasis in this and following cases added) [2]
- A Seattle researcher found in 1988 that firefighters under age 40 who served in four cities from 1945 to 1980 were **60% more likely** than other Americans to die of cancer.[3]
- A researcher at the University of Alberta in Edmonton found that there was **"no strong evidence"** of increased risk of lung cancer, heart disease or obstructive pulmonary disease among firefighters. and that the death rates of fire fighters from all causes and from heart disease were "close to the expected standardized mortality ratio." [4]

Also, a 1991 California study on causes of death among San Francisco firefighters found a lower than expected overall death rate among more than 3,000 fire fighters employed between 1940 and 1970 and **"fewer cancer deaths than expected."** The study did find excess deaths from esophageal cancer, cirrhosis and other liver diseases.[5]

"These **increased risks may have been due to toxic exposure, alcohol consumption, or interaction between alcohol and toxic exposure,**" the researchers concluded. "...Taken as a whole the **studies published to date** (including the present study) **do not consistently show increased risk for any type of cancer.**"

A 1994 study of deaths among firefighters in metropolitan Toronto[6] found a lower than expected number of deaths from all causes but **"some evidence"** of an increased risk of death from cancer of the brain, "ill-defined" cancers ("other malignant neoplasms) and aortic aneurysms.

The researchers were unequivocal only in their conclusion about brain cancer.

"Despite conflicting results for various cancer sites from epidemiologic studies, excess brain cancer mortality is consistently related to fire fighting," they said.

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[1] Francis X. Mahoney Jr., JOURNAL OF THE NATIONAL CANCER INSTITUTE, Vol. 83, No. 13, July 3, 1991
[2] Geoffrey R. Howe & J. David Burch, AMERICAN JOURNAL OF EPIDEMIOLOGY, Vol. 132, No. 6, December 1990
[3] citation unavailable
[4] Tee L. Guidotti, AMERICAN JOURNAL OF INDUSTRIAL MEDICINE, Vol. 23, p. 921-940 (1993) (Not yet published in 1991.)
[5] James J. Beaumont et. al., AMERICAN JOURNAL OF INDUSTRIAL MEDICINE, Vol. 19, p. 357-372 (1991)
[6] Kristan J. Aronson et. al., AMERICAN JOURNAL OF INDUSTRIAL MEDICINE, Vol. 26, p. 89-101 (1994)

Some other research:

- A 1992 study of more than 4,500 fire fighters in Seattle, Tacoma and Portland found "**no excess risk of overall mortality from cancer but excesses of brain tumours...and lymphatic and haematopoietic cancers.**"[7]
- A 1978 study of Boston fire fighters found "**inconsistent evidence** for an increased risk of mortality from cardiovascular disease, respiratory disease, cancer and accidents." [8]
- A 1990 study of fire fighters in Denmark found **a significant increase in lung cancer** in older firefighters and increased non-pulmonary cancer among younger fire fighters.[9]
- A 1987 study of more than 1,800 fire fighters in Buffalo **found fewer than expected deaths from all causes** but higher than expected incidence of colon and bladder cancer.[10]
- A 1986 study of New Jersey fire fighters found **an increase in skin cancer** and cirrhosis.[11]
- A 1995 study of Parisian fire fighters found a "**far lower overall mortality**" than the typical French male, but **greater than expected deaths from genito-urinary cancer.**[12]
- A 1984 study of fire fighters in western Australia found "**no evidence of increased mortality** from cardiovascular or respiratory disease, or from any other cause."[13]
- A 1994 study of male firefighters in Seattle and Tacoma, Wash., found cancer risk among firefighters "**similar to both the police and the general male population** for the common sites."[14]
- A 1994 study of fire fighters in Stockholm found "**cancer incidence...equal to the expected.**"[15]

Howe and Burch, *op. cit.*, reviewed six of the studies cited above, and concluded that overall there were 68 fewer cancer deaths than expected among the 15,800 fire fighters tracked in the six studies. From those studies and others they found "**substantial evidence ... that no association exists between the occupation of fire fighter and risk of overall cancer mortality.**"[16]

Risk for Specific Cancers:

1997 Senate Bill 329 would create a presumption that various types of cancer contracted by fire fighters were caused by his or her employment. Among the cancers cited in the bill:

Skin Cancer: "Although there is some evidence of a statistical association between fire fighting and increased risk of malignant melanoma, **there is little evidence to support the causality** of the association," Canadian researchers found.[17]

Bone Cancer: "Overall, **the conclusion must be very tentative because of limited numbers,** but **there appears to be some evidence of a positive association** for multiple myeloma," the same researchers concluded.[18]

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[7] P.A. Demers et. al., BRITISH JOURNAL OF INDUSTRIAL MEDICINE, September 1992, p. 664-670.
[8] A.W. Musk, et. al., BRITISH JOURNAL OF INDUSTRIAL MEDICINE, May 1978, p. 104-108.
[9] E.S. Hansen, BRITISH JOURNAL OF INDUSTRIAL MEDICINE, December 1990, p. 805-809.
[10] J.E. Vena, R.C. Fiedler, AMERICAN JOURNAL OF INDUSTRIAL MEDICINE, Vol. 11, p. 671-684.
[11] E. Feuer, K. Rosenman, AMERICAN JOURNAL OF INDUSTRIAL MEDICINE, Vol. 9, p. 517-527.
[12] S. Deschamps, et. al., EUROPEAN JOURNAL OF EPIDEMIOLOGY, December, 1995, p. 643-646.
[13] E. Eliopulos, et. al., BRITISH JOURNAL OF INDUSTRIAL MEDICINE, May 1984, p. 183-187.
[14] P.A. Demers, et. al., CANCER CAUSES CONTROL, March 1994, p. 129-135.
[15] Goran Tornling, et. al., AMERICAN JOURNAL OF INDUSTRIAL MEDICINE, February, 1994, p. 219-228.
[16] Howe & Burch, *op. cit.*, p. 1043.
[17] *Ibid*, p. 1047.
[18] *Ibid*, p 1047.

Digestive System Cancer

a. Colon Cancer: Only the Buffalo study uncovered any evidence of a link between colon cancer and fire fighting, the Canadian researchers reported. "It therefore appears that **the weight of evidence favors the lack of any association**," they wrote.[19]

b. Rectal Cancer: Of nine studies, three found fewer than expected cases among fire fighters, and just two found more than a 50-50 chance that a case of rectal cancer was job-related.[20] Another researcher found three studies in which deaths from rectal cancer occurred at twice the expected rate, but a more recent study found **rectal cancer incidence was no different** among fire fighters, police and the general population.[21] Findings like these prompted Dr. Tee L. Guidotti to conclude that there was **"no defensible general presumption of risk."**[22]

c. Pancreatic Cancer: "In general, epidemiological data suggest that firefighting is not associated with cancer of the pancreas," researchers at Mt. Sinai School of Medicine concluded. One study found a "large but nonsignificant" elevation of pancreatic cancers compared with police officers; four reported risk equal to the general population.[23]

d. Liver Cancer: Liver cancer is a rare disease. Researchers at Mt. Sinai School of Medicine analyzed studies ranging from **the San Francisco study** that **found a twofold excess** of liver cancer mortality among firefighters to the Stockholm study, which found lower than expected incidence of liver cancer. **Three studies showed no association between fire fighting and liver cancer,** they reported.[24]

e. Stomach and Esophageal Cancer: Seven studies that the Mt. Sinai team analyzed found a positive association between stomach cancer and fire fighting, but none of the numbers were statistically significant. Three studies found a positive association for esophageal cancer, and three found a negative association.[25] A California study concluded that **increased risks** of esophageal cancer **"may have been due to firefighter exposures, alcohol consumption, or interaction between alcohol and exposures."**[26]

Lymphatic and Hematopoietic Cancer: "There is some evidence for both an association and a general presumption or risk," Canadian scientists reported in 1995. **"However, the aggregation is medically meaningless."** We therefore recommend a case by case approach.[27]

Other cancers cited in SB 329: The evidence on other cancers enumerated in the bill is cited in the studies footnoted here, but for space reasons is not summarized.

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[19] *Ibid,* p. 1044.
[20] Guidotti, AMERICAN JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL MEDICINE, December, 1995, p. 1352.
[21] Ann L. Golden, et. al., OCCUPATIONAL MEDICINE, Vol. 10, No. 4, December, 1995.
[22] Guidotti, *op. cit.*, p. 1351
[23] Golden, , *op. cit.*, p 814.
[24] *Ibid.*
[25] *Ibid.*
[26] Beaumont, *op cit,* p 357.
[27] Guidotti, *op cit,* p. 1348.

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TESTIMONY OF
MARK D. ZEIER
STATE PRESIDENT
PROFESSIONAL FIRE FIGHTERS OF WI
ON SB-329
TO
ASSEMBLY COMMITTEE ON GOVERNMENT OPERATIONS
MARCH 17, 1998

I want to thank the committee for holding this hearing and a special thank you to those committee members that are sponsors of SB-329.

My name is Mark Zeier. I am the State President of the PFFW. I also have been a fire fighter for the City of Sheboygan for 26 years.

I am here representing the 2,500 men and women career fire fighters from 56 Wisconsin communities. We are asking for this legislation because nearly one fire fighter dies annually of a type of cancer related to our profession.

I also want to offer a special thanks to the original authors of a similar bill that was introduced in the 1989 session. They are the ones that really deserve credit for recognizing several years ago, the seriousness of the incidence of cancer among fire fighters. I am referring to former State Representative John Antaramian, now mayor of the City of Kenosha and former State Representative Jeanette Bell, now the mayor of West Allis. Mayor Antaramian was the chief author of the 1989 bill and Mayor Bell was one of the cosponsors.

Unfortunately, in 1989 we did not have the detailed evidence of cancer among Wisconsin fire fighters that we do today.

Here is what is happening in Wisconsin:

In the last 20 years, 26 fire fighters developed a type of cancer covered by this bill that can be medically linked to fire fighting.

Of the 26, 16 were under the age of 50 and would have been eligible for these benefits. Those over 50 were eligible for other retirement benefits and only partially covered by this legislation.

Of these 16, 10 died within one year of having to leave the job. Most of the others died shortly after that.

The average age of these 16 was 47 years and had been a fire fighter for 20.7 years.

This legislation is designed to assist families like these 16. Currently, Wisconsin provides disability benefits to those fire fighters and police officers that are injured in the line of duty. To be eligible for the Duty Disability or 40.65 benefits, the disability must be permanent and the employe has the burden to prove the injury was duty related.

Unfortunately, this system is not adequate to cover all the occupational diseases that are prevalent among fire fighters. The most common occupational diseases among fire fighters are heart and lung diseases, including lung cancer. In the 1960's, the Legislature saw fit to create the Heart and Lung Disease Program for fire fighters.

Under Heart and Lung, it is presumed that if a fire fighter gets these diseases, they are duty related and the fire fighter is eligible for disability benefits. The level of benefits is generally 80% of their salary.

Though it is difficult to prove that an individual fire fighter developed a specific disease due to their occupation, medical research has shown that the incidence of these diseases is much higher among fire fighters.

The same is true with certain types of cancers. Studies have shown that fire fighters have higher rates of cancer than the general public and other protective professions like law enforcement.

Job related cancer is difficult to prove on a case by case basis. We know from studies that this is true, but

to prove that a specific fire fighter got a specific cancer from exposure at certain fires is next to impossible.

In 1995, 3 doctors from the Mount Sinai School of Medicine and a distinguished advisory committee of 10 medical doctors reviewed the available medical information on the carcinogenic hazards encountered in fire fighting and the results of medical studies of cancer in fire fighters.

They analyzed 19 separate medical studies of cancer in fire fighters published in medical studies. The 19 studies occurred over nearly a 20-year period and was conducted of fire fighters in Illinois, Massachusetts, Washington, Oregon, New Jersey and California. Studies of Canadian fire fighters in Toronto and Alberta were analyzed as well as studies in Sweden, Finland and Australia.

A copy of the study is included in your packet of information.

Reading from the conclusion or discussion found on page 816 we find "These studies clearly demonstrate increased risk of several cancers that can be plausibly linked with carcinogenic exposures encountered by fire fighters in their work. The data most strongly suggest that fire fighters are at increased risk of developing and dying from leukemia, nonHodgkins' lymphoma, multiple myeloma, and cancers of the brain and bladder. The majority of studies that examined these cancers found markedly elevated risks for fire fighters, 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 fire fighting environment that are known or suspected causes of these cancers. Weaker but still plausible evidence links fire fighting to increased risk of rectal, colon, stomach, and prostate cancers and melanoma."

Therefore we are seeking this legislation. It will be presumed that a fire fighter's cancer, if of a certain type, was duty related and therefore eligible for disability benefits.

This presumption does not guarantee disability benefits. The employer would still have the opportunity to contest the granting of benefits.

As I pointed out, most fire fighters who have to leave the profession with a disabling cancer, usually succumb to the disease in the first year so the disability benefit that we are talking about providing in this legislation really becomes a survivors benefit for the family.

Some may ask why cancer among fire fighters is a growing problem today with all the sophisticated equipment they use?

The fires we are fighting today are much worse than 25-30 years ago! With so many new chemicals in use today, with so many building materials being made from something other than wood and steel, today's fire are simply more dangerous and we are exposed to numerous carcinogenic agents than ever before!

Since the PFFW first worked with the authors of this bill last year, one fire fighter, Don Asselin of La Crosse has died of cancer. In Sheboygan we lost one fire fighter to cancer in 1989.

I would also like to address the economic issues regarding SB-329.

We have made every effort to keep the cost of this cancer insurance policy as low as possible. Here is how the cancer presumption would work in comparison to the current regular 40.65 disability program or the current heart and lung program.

If a fire fighter utilizes the cancer presumption benefit that SB-329 would provide, they would not be able to withdraw their employe contributions as a lump sum from the Wisconsin retirement system. At the current time, fire fighters can withdraw their employe contributions still collect disability benefits.

By leaving the employe contributions in the system, the combined cost of the retirement system and the disability system for employers should be kept to a minimum.

Employers, led by the Alliance of Cities, are quick to criticize the cost of the current duty disability system. They like to show how the cost of the system continues to increase. What they fail to tell you is that while the cost of disability might be increasing, their cost of normal retirement for fire fighters is decreasing by a significant amount.

During the past 5 years, employer WRS contributions for fire fighters have decreased by nearly 33% while for the general class of public employes there has been little change.

In order for you to understand the total cost of these programs, I believe it is important to look at both programs at the same time. It is simply not accurate to look at the 40.65 disability program in a vacuum.

Even the respected Blair Testin has told the legislature on several occasions that there is a direct relation between the two costs.

You may have heard the Alliance of Cities complain about duty disability but I don't believe you have heard them complain about the heart and lung program dealing with diseases. Their complaints seem to be with injured workers that they think might some day be physically fit to be able to return to work. Maybe they might have an issue that the legislature might want to look at some time.

The cancer presumption bill should not be held hostage due to their concerns with duty disability!

Most fire fighters developing cancer die within one year of leaving the job. I don't think anyone can argue that cancer victims are likely to somehow abuse the system.

I also want to point out that only those fire fighters with cancers that are disabling are eligible for benefits. Some fire fighters with certain types of cancers are able to work after recovering from their disease. We

are only talking here about cancers that are permanently disabling.

Another reason why a comparison to duty disability is inaccurate is the difference between the disabilities. Under 40.65 the injuries are often not life threatening such as back problems. These type of disabilities are likely to see the individual collecting benefits for many years.

Under the 40.65 program the benefit level is 80% of salary. Since most fire fighters with cancer die shortly after developing the disease, most families will not realize that 80%. Surviving families receive 70% of the 80% or about 50% of the income when the fire fighter was able to work.

The average fire fighter dying from cancer has been in the fire service for 20 years and thus have already developed 50% of their total retirement package. That is 20 years times our multiplier of 2.5 or 50%.

We estimate that the actual cost, using the ETF actuarial is a little over $100 per year per fire fighter. The average Wisconsin fire fighter earns $40,000 annually. One fourth of one percent of that is $100 or $8 per month. We think that is pretty inexpensive cancer insurance.

From our analysis you can see that we have made efforts to keep the cost of this cancer presumption legislation down and therefore we do not expect to see any serious costs of this for employers.

Seventeen other states have already recognized the severity of this problem and have enacted cancer presumption legislation. We think it is time that Wisconsin acts on this as well.

Thank you for your time and attention.

ANNE L. GOLDEN, PHD
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THE RISK OF CANCER IN FIREFIGHTERS

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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

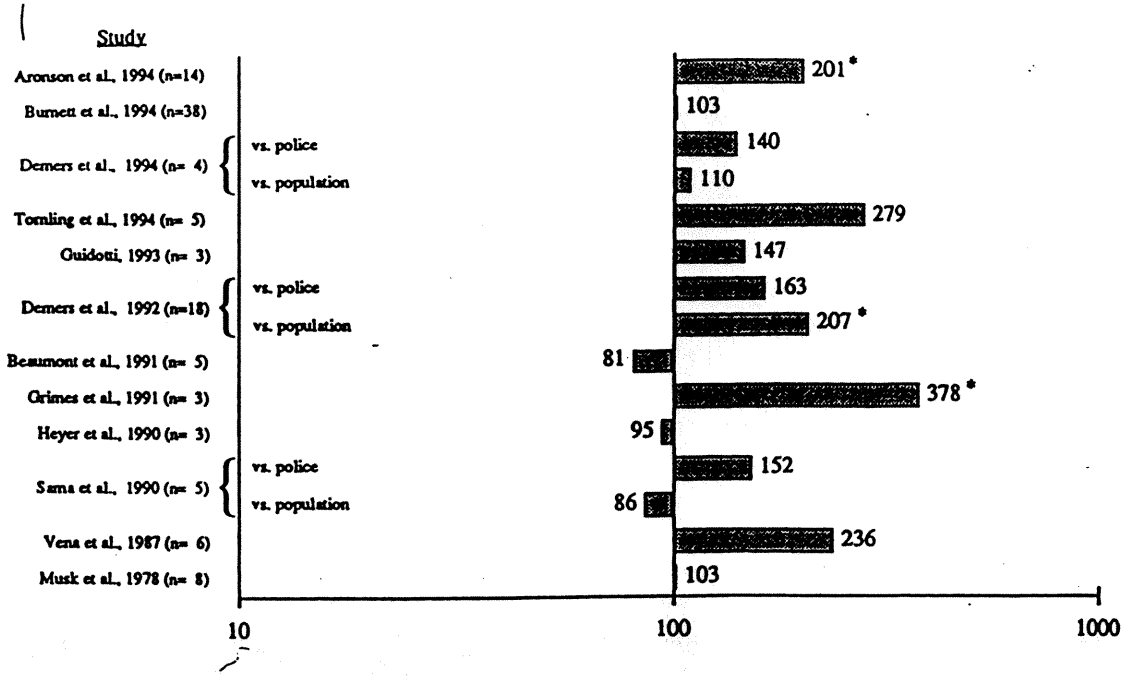

FIGURE 1. Brain cancer risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 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, dur-

ation 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 myeloma 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).

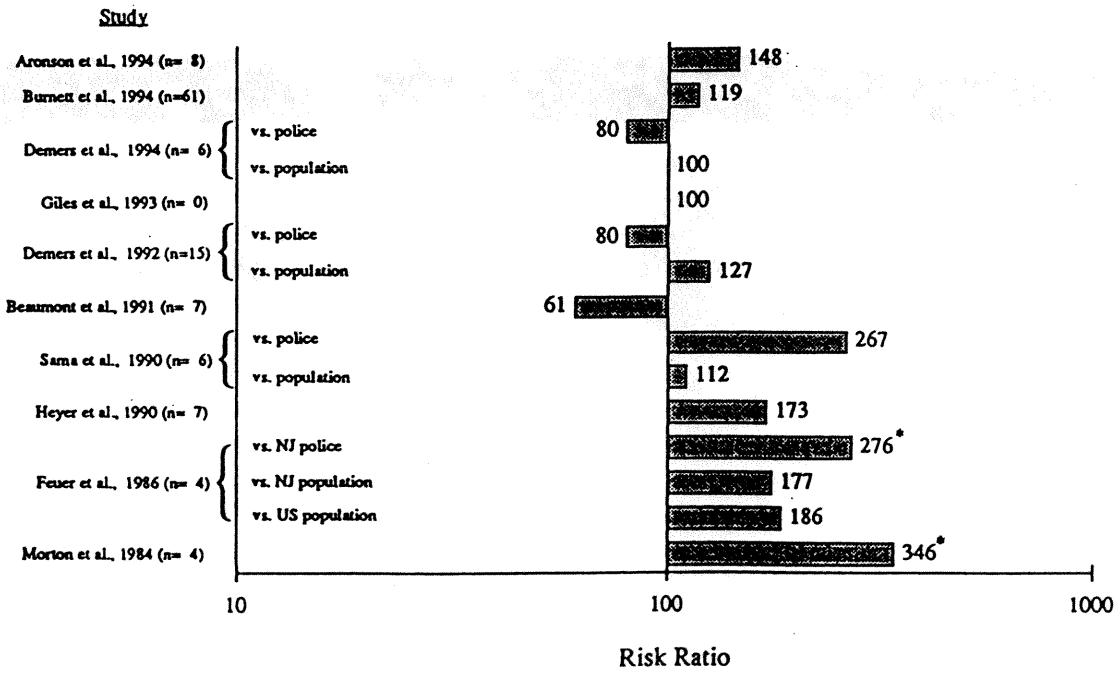

FIGURE 2. Leukemia risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 on $\log^{10}$ 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-

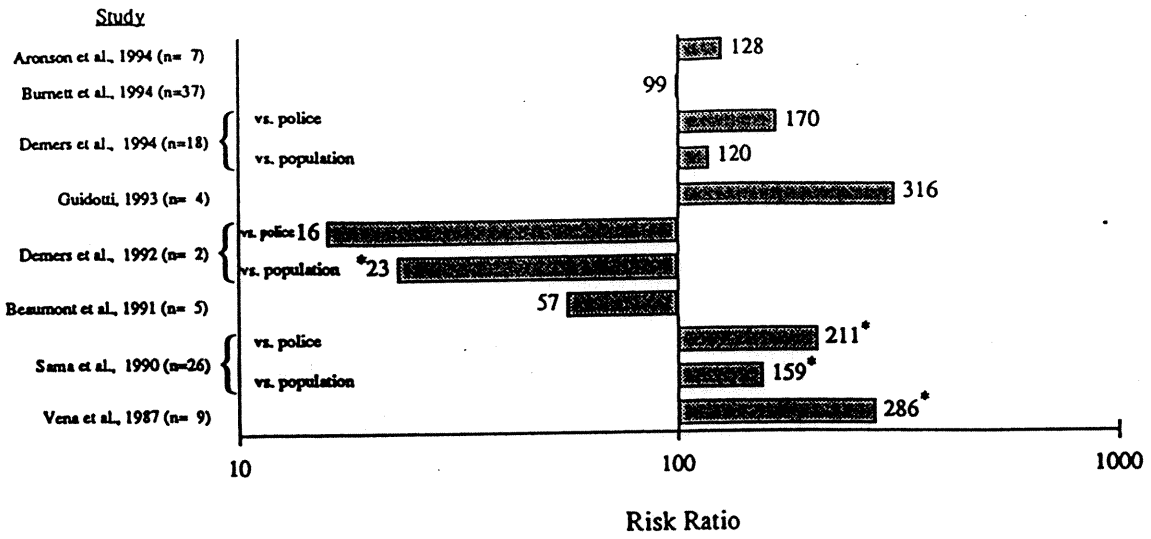

FIGURE 3. Bladder cancer risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 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.

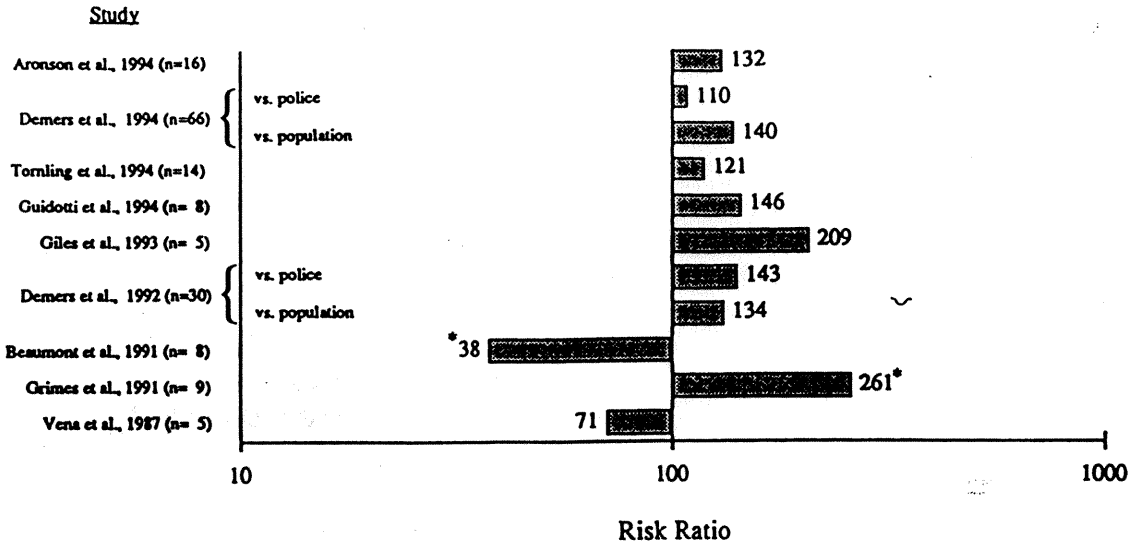

FIGURE 4. Prostate cancer risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 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

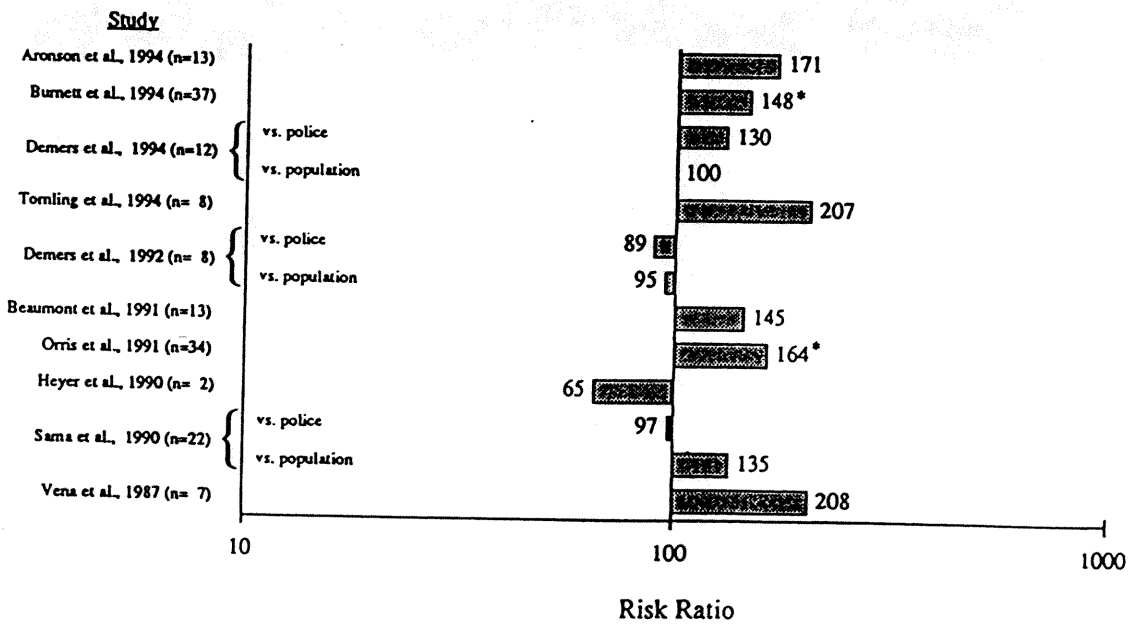

FIGURE 5. Rectal cancer risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 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]

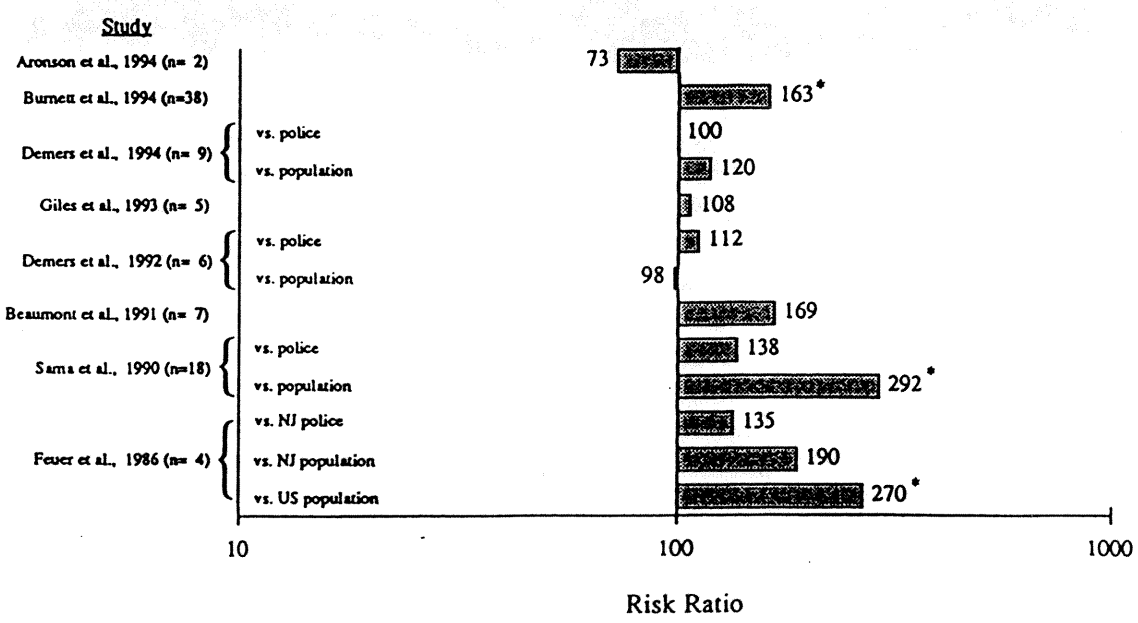

FIGURE 6. Skin cancer risk estimates for firefighters from published epidemiologic studies. Studies listed by first author and publication year (n = observed number of cancers among firefighters). Risk ratio expressed by authors as SMR, PMR, SIR, or RR, with null value (no excess risk) equaling 100 on $\log^{10}$ 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 myeloma) underscore the importance of understanding and reducing the cancer risks attributable to firefighting.

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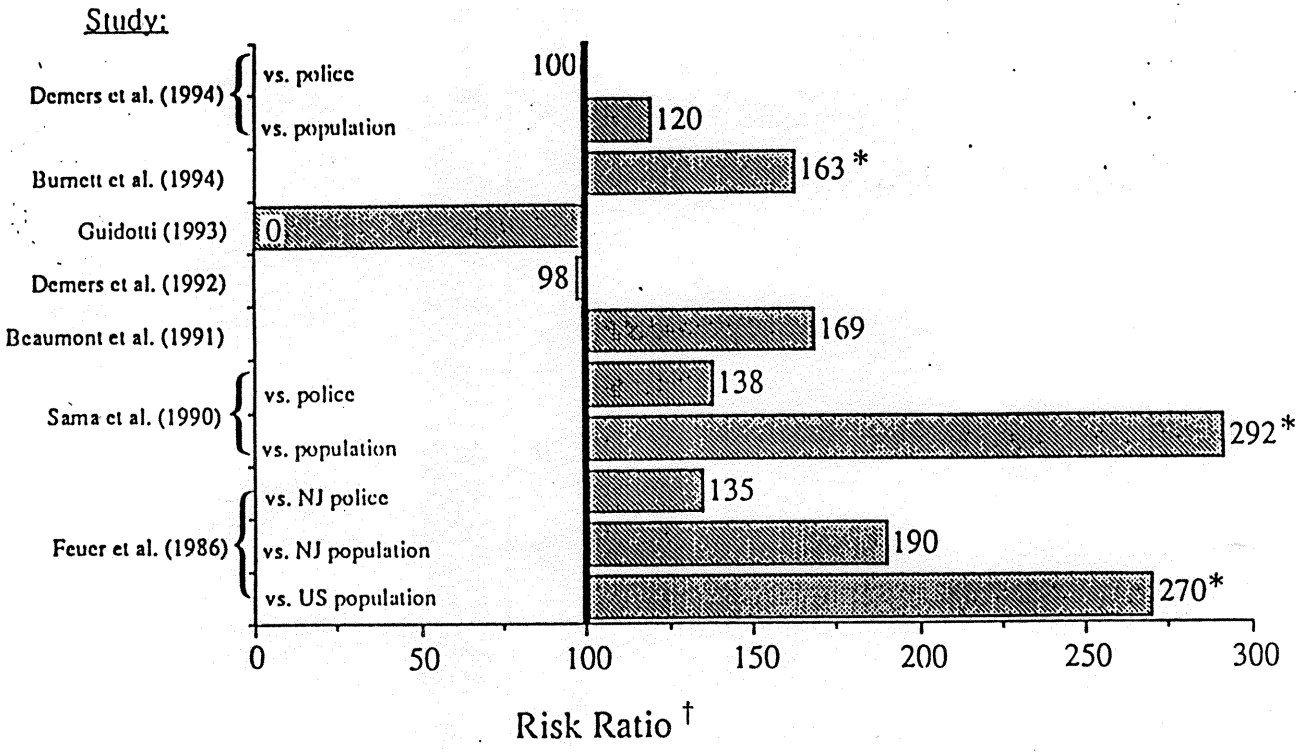
FIGURE 7

SKIN CANCER AMONG FIREFIGHTERS



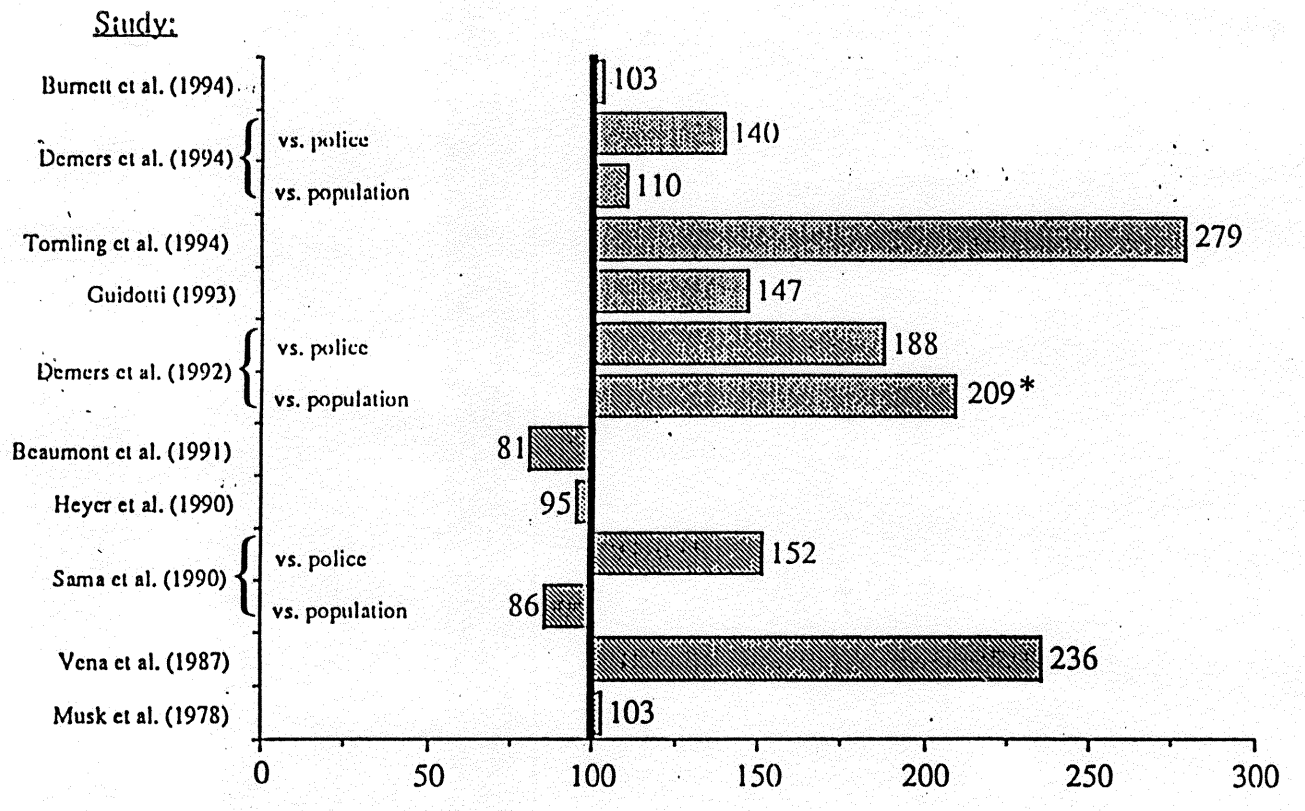
†Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

*Statistically significant increase in risk.

This graph shows that the skin cancer risk of firefighters is markedly higher (up to 200% excess risk) compared to that of the general population. Most studies did not separate melanoma from non-melanoma skin cancers. However, because these studies were based on mortality rates, it is likely that most of the skin cancers were, in fact, melanoma, since the other forms of skin cancer are rarely fatal.

FIGURE 1

BRAIN CANCER AMONG FIREFIGHTERS

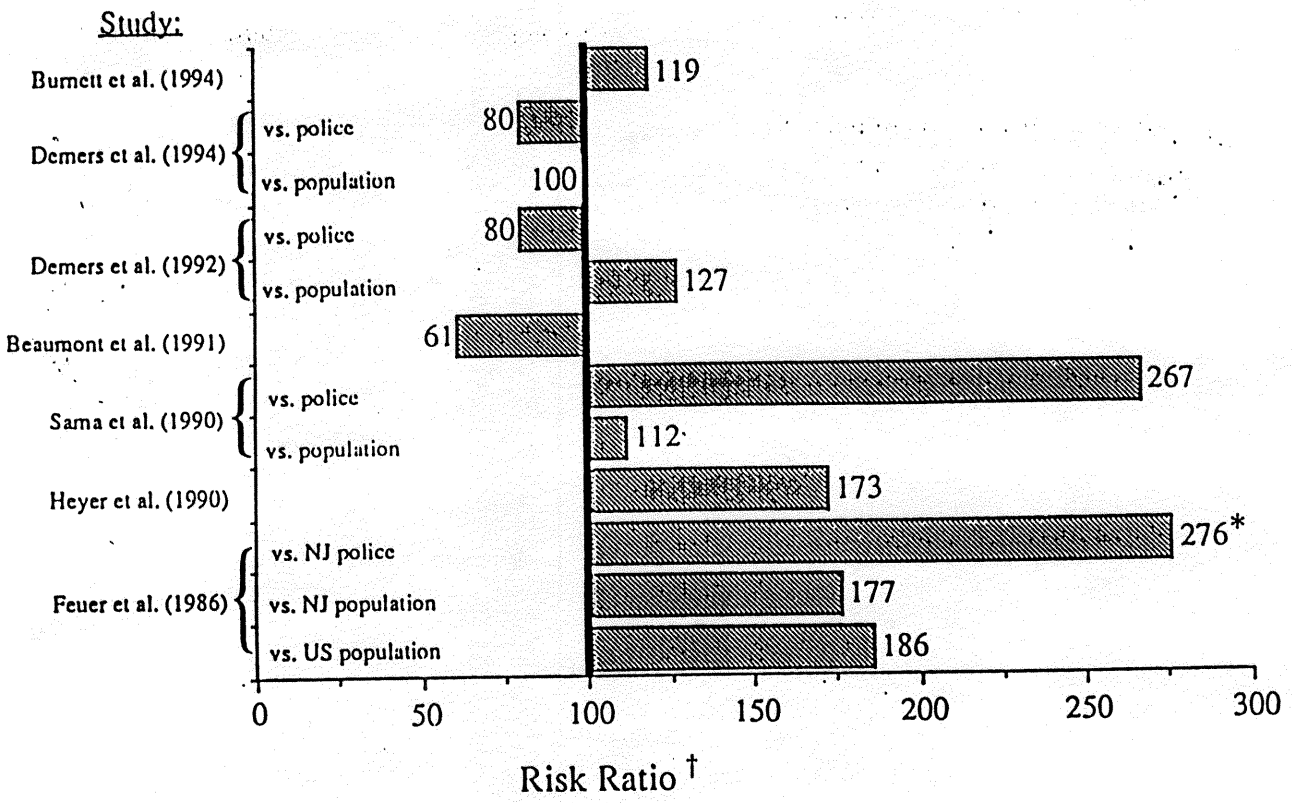


†Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

*Statistically significant increase in risk.

Several studies have found elevated risk of brain cancer among firefighters. Generally, this excess risk occurs among younger firefighters and within 15-30 years of hire, i.e., after a relatively short latency period.

LEUKEMIA AMONG FIREFIGHTERS

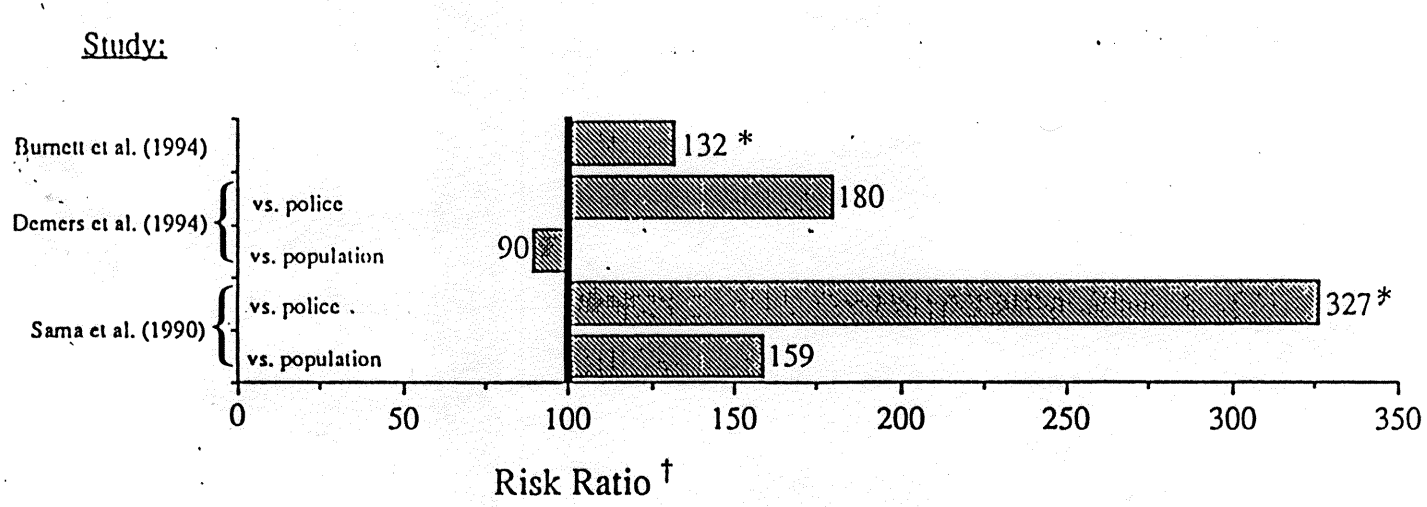


† Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

* Statistically significant increase in risk.

This graph demonstrates that, in the majority of studies, firefighters clearly have excess risk of leukemia - almost 3 times the risk of police officers in some reports.

NON-HODGKIN'S LYMPHOMA AMONG FIREFIGHTERS



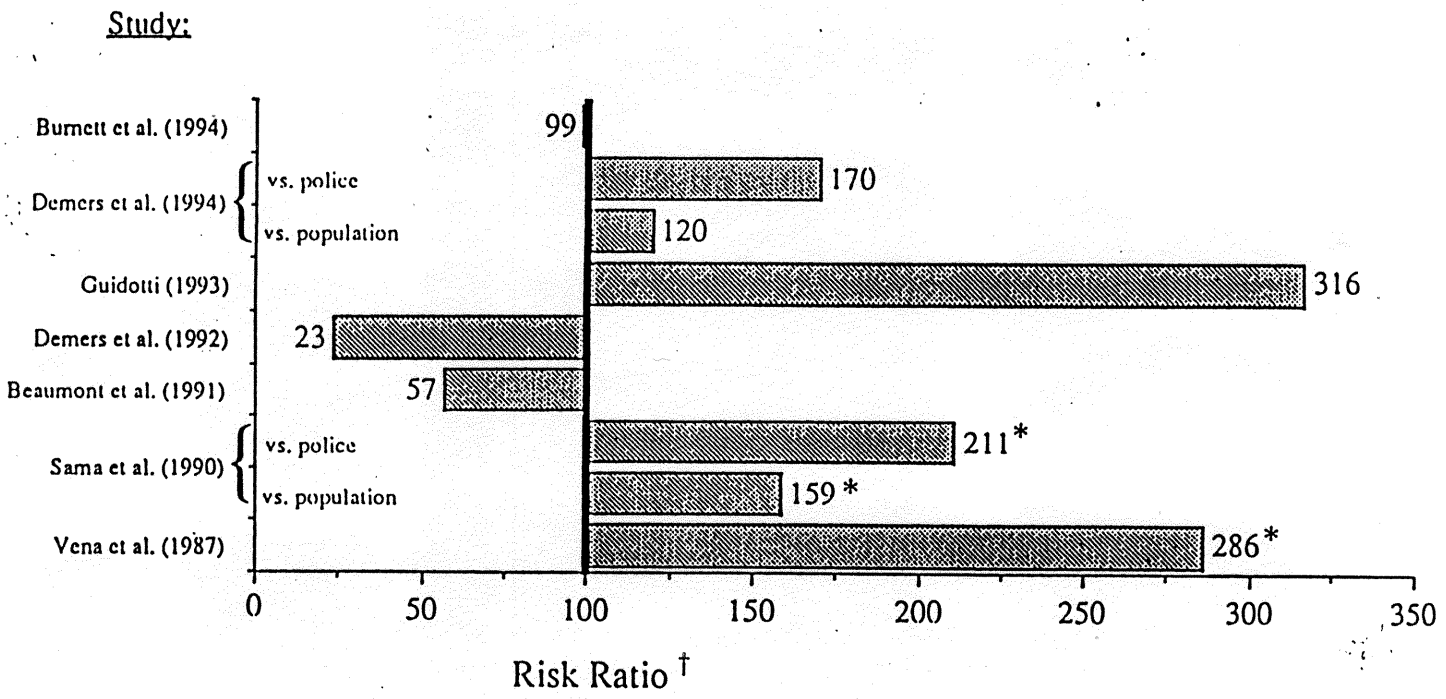
† Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

*Statistically significant increase in risk.

All of the studies that looked at lymphoma found excess risk among firefighters, in comparison to police or the general population. The association with firefighting is strong and statistically significant in 2 of the studies.

FIGURE 4

BLADDER CANCER AMONG FIREFIGHTERS



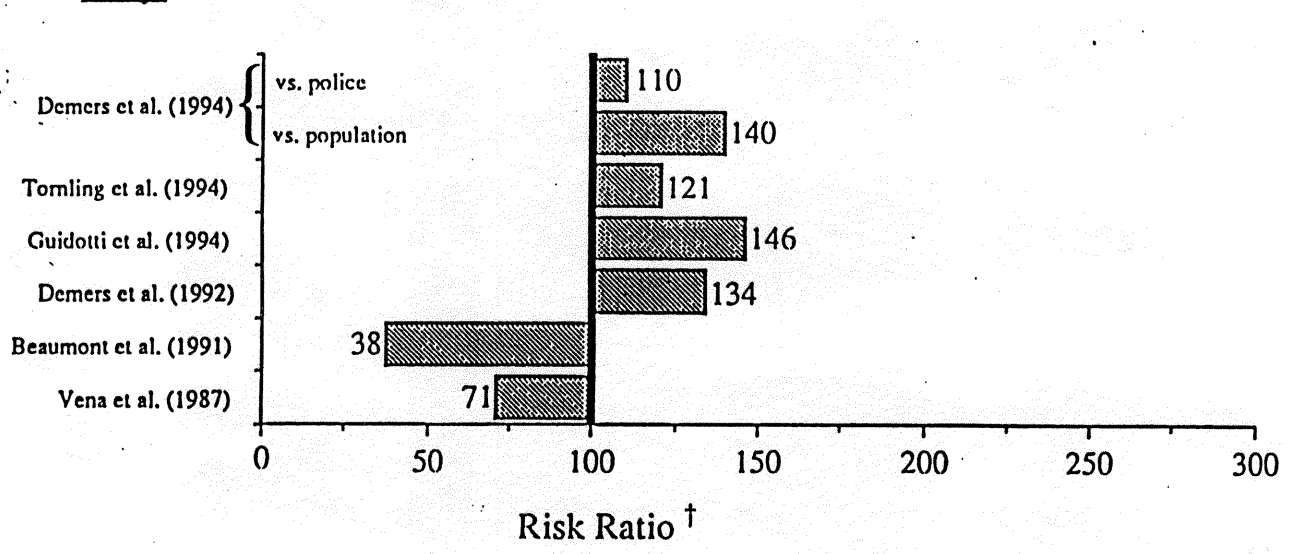
† Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

* Statistically significant increase in risk.

The preponderance of evidence from these studies clearly implicates firefighting as a risk factor for bladder cancer. The excess risk among firefighters may be as high as 200%.

FIGURE 5

PROSTATE CANCER AMONG FIREFIGHTERS

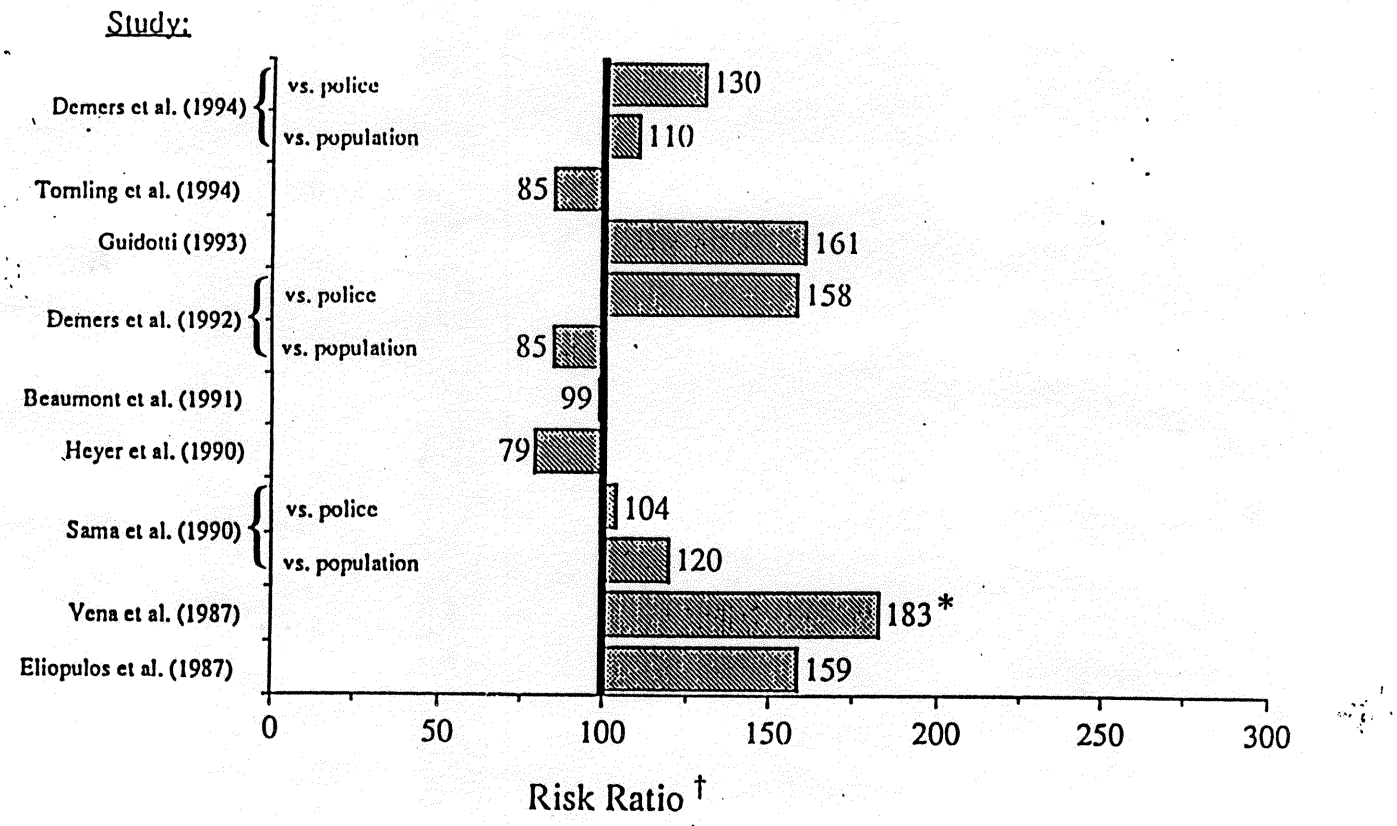


† Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

Recent studies have consistently shown that prostate cancer is in excess among firefighters, compared to the general public.

FIGURE 6

COLON CANCER AMONG FIREFIGHTERS



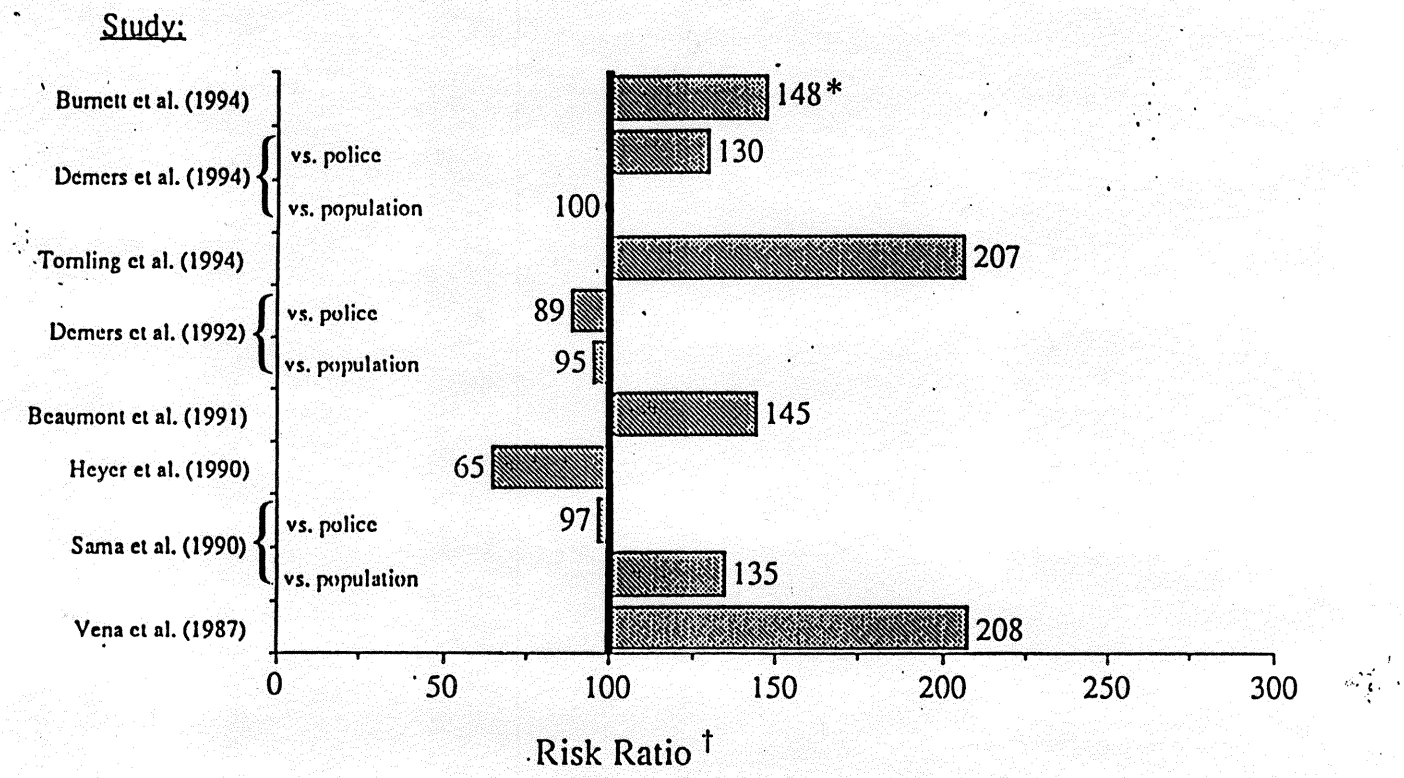
[1]Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

*Statistically significant increase in risk.

Many studies looked at colon cancer and this graph demonstrates the consistent moderate to high excess risk found for firefighters.

FIGURE 8

RECTAL CANCER AMONG FIREFIGHTERS



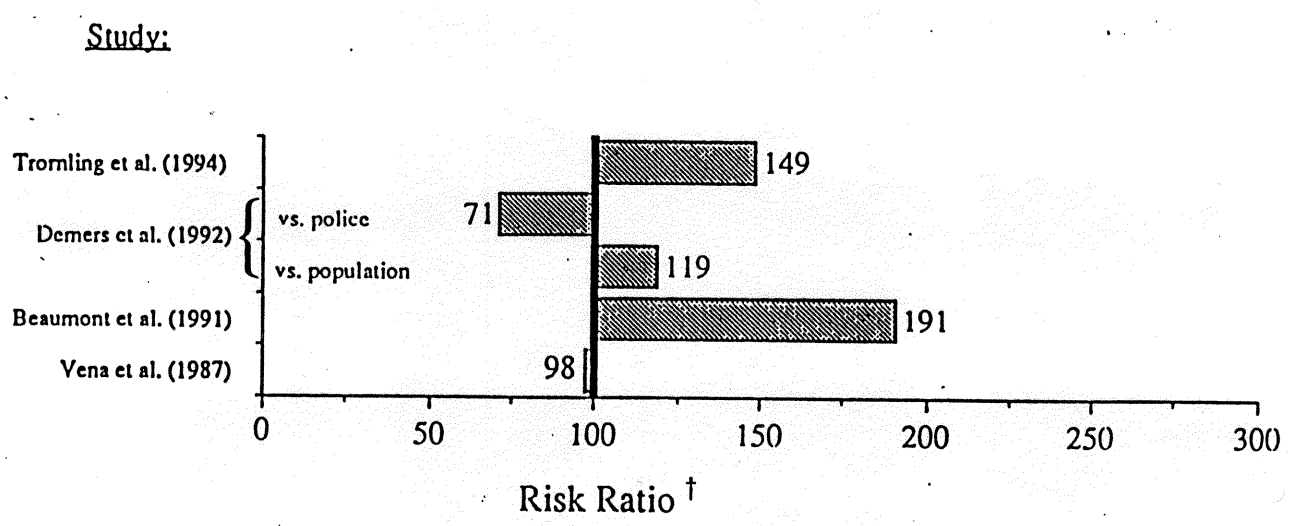
†Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

*Statistically significant increase in risk.

These studies show that the risk of cancer of the rectum among firefighters appears to be even higher than the risk of colon cancer.

FIGURE 9

LIVER CANCER AMONG FIREFIGHTERS

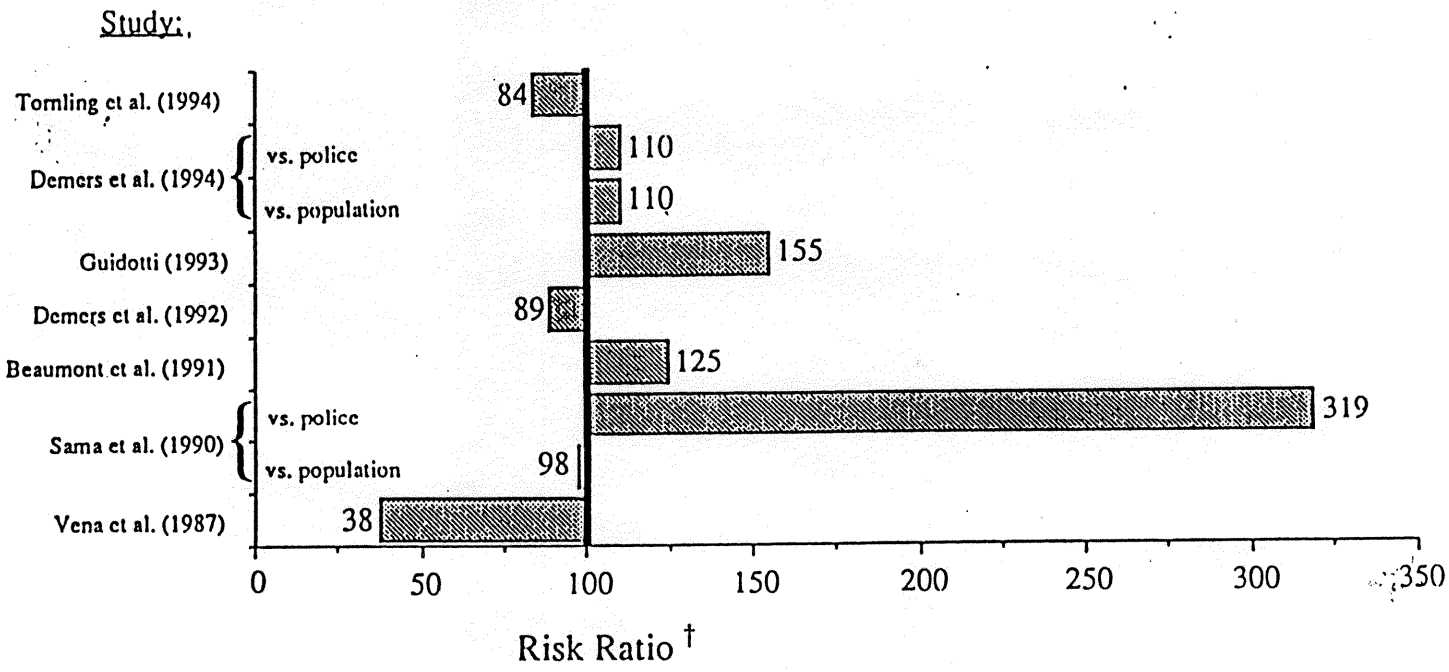


†Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

This graph indicates that in most studies, the risk of liver cancer was higher for firefighters than for the general population.

FIGURE 10

PANCREATIC CANCER AMONG FIREFIGHTERS

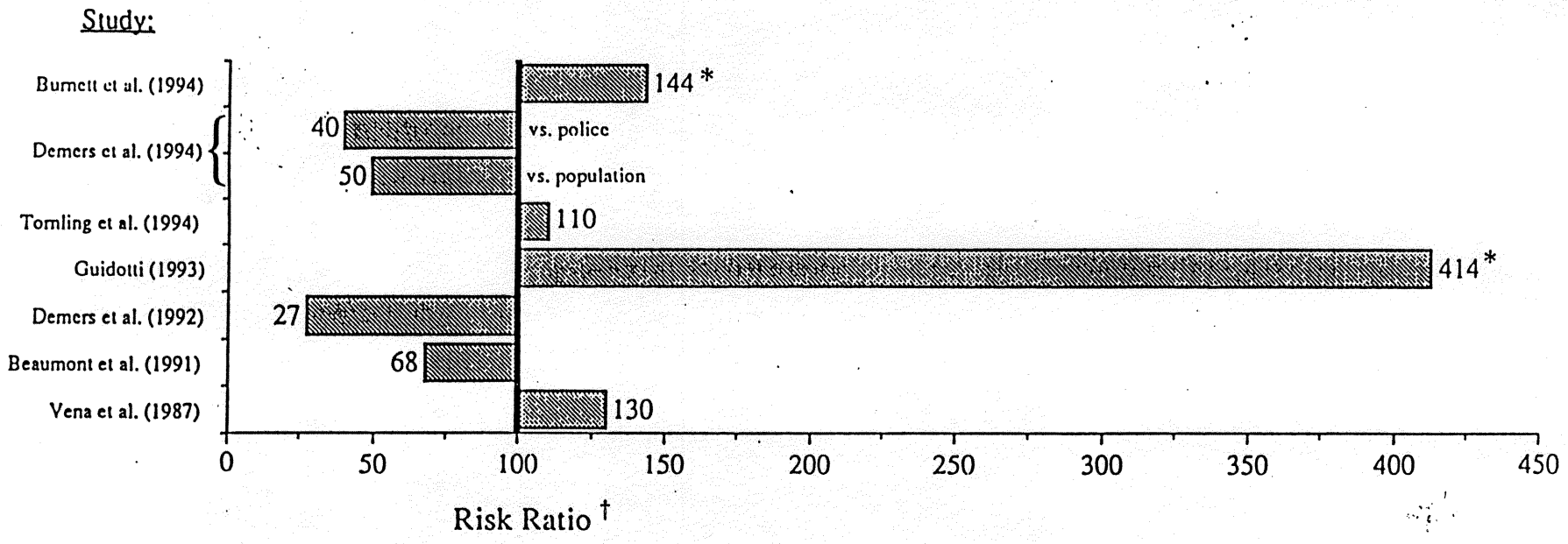


† Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

Most studies showed a small to moderate increase in **cancer of the pancreas** among firefighters, although 1 study found that firefighters had more than 3 times the risk of police officers.

FIGURE 11

KIDNEY CANCER AMONG FIREFIGHTERS



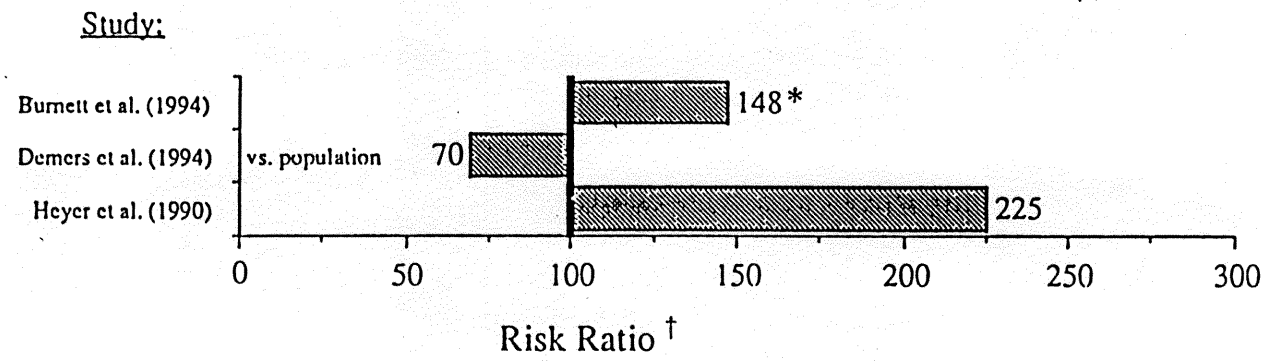
†Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

*Statistically significant increase in risk.

The excess risk of **kidney cancer** among firefighters was statistically significant in 2 studies. Some studies did find lower than average risk in firefighters.

FIGURE 12

MULTIPLE MYELOMA AMONG FIREFIGHTERS

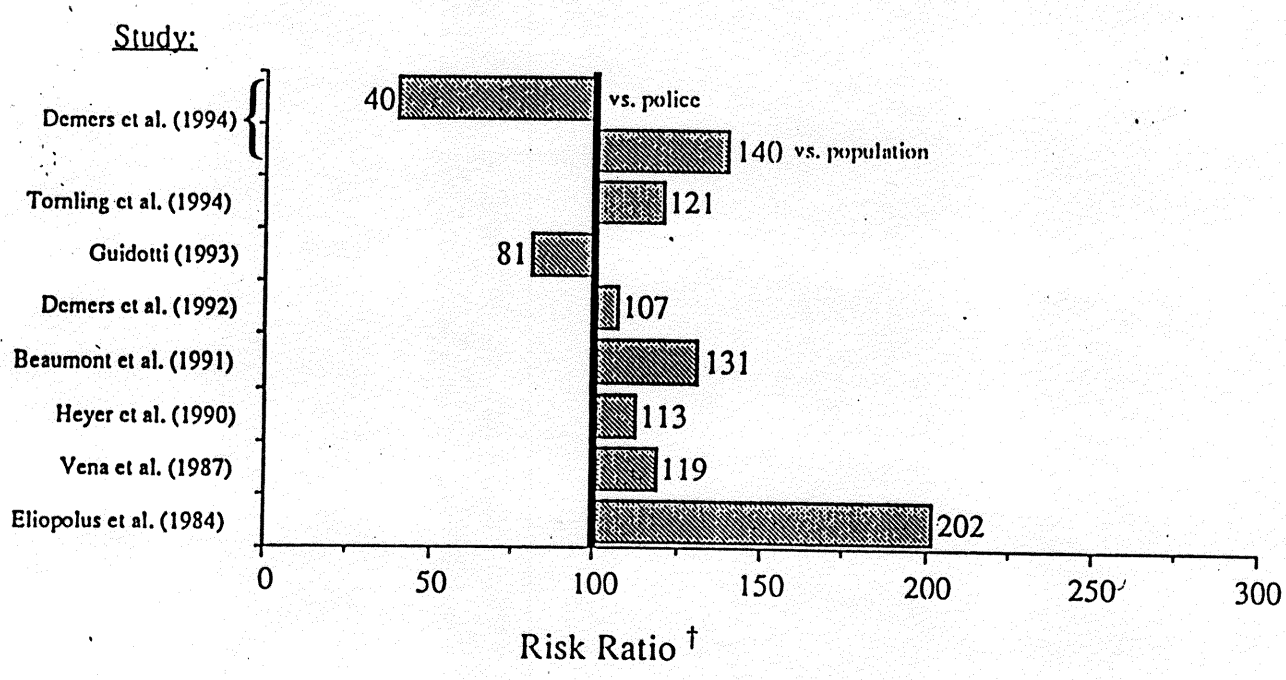


† Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

* Statistically significant increase in risk.

Multiple myeloma was strongly associated with firefighting in 2 of these 3 studies. An analysis that combined the results of all the available studies (Howe and Burch) determined that multiple myeloma was one of the 3 cancers most consistently associated with firefighting.

STOMACH CANCER AMONG FIREFIGHTERS

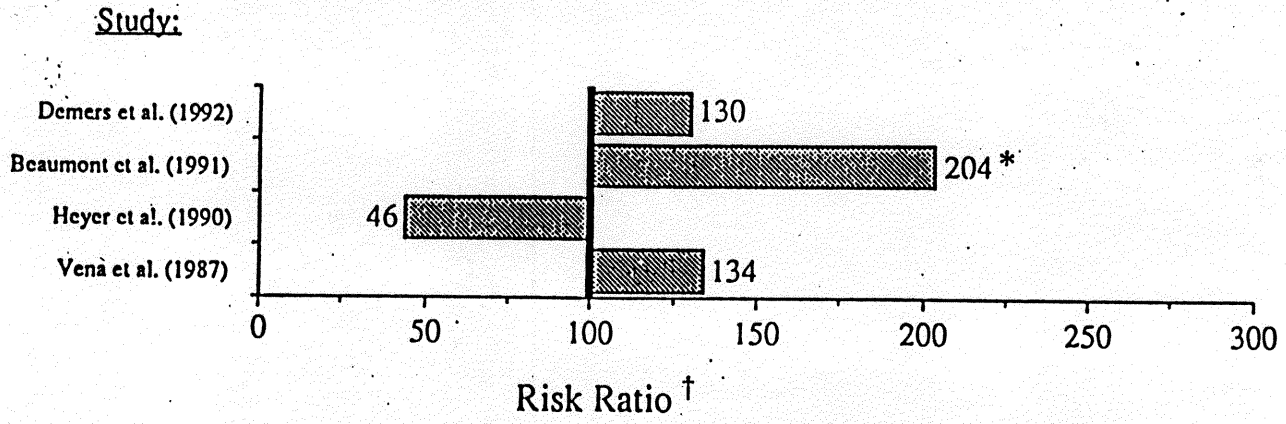


† Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

This graph demonstrates that firefighters have consistently been shown to have higher rates of stomach cancer than the general public.

FIGURE 14

ESOPHAGEAL CANCER AMONG FIREFIGHTERS



† Risk Ratio: SMR, PMR, or RR. Null value (no excess risk) equals 100.

* Statistically significant increase in risk.

The majority of studies that included cancer of the esophagus showed that firefighters are at increased risk.