

# UNIFORMED PROFESSIONAL FIRE FIGHTERS ASSOCIATION OF CONNECTICUT

AFFILIATED WITH INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

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Senator Prague and Representative Ryan and members of the Labor and Public Employees Committee.

My name is Dominic M. Cutaia. I am the Chairman of the Legislative Committee for the Uniformed Professional Fire Fighters Association of Connecticut (UPFFA of CT). The UPFFA of CT represents approximately 4,000 career Fire Fighters across the State of Connecticut. I am also the President of the Professional Fire Fighters of Manchester, Local 1579 of the International Association of Fire Fighters. I have been an officer with my local union since 1991.

Thank you for holding this public hearing on **Raised Bill 6956 AN ACT CONCERNING WORKERS' COMPENSATION COVERAGE FOR FIREFIGHTERS AND POLICE OFFICERS**. This bill is a top priority for not only our members but also their families.

During today's hearing, you will hear testimony from:

- A widow of a fallen Brother Fire Fighter
- A representative of the International Association of Fire Fighters
- Members of our association who would be impacted by the proposed legislation

As you may already be aware, there are several states across this Country that already have similar legislation in their state to protect their Fire Fighters. Included in these States are our three (3) neighboring states, New York, Massachusetts, and Rhode Island. During today's hearing you will hear from a representative from the Professional Fire Fighters of Massachusetts.

As I mentioned earlier, I am also the President of the Professional Fire Fighters of Manchester. My Local represents the seventy (70) men and women that respond to the over 7,800 fire, medical, rescue, hazardous materials, and other miscellaneous calls in Manchester. Two (2) of my members that would be affected by legislation are here to testify to this committee.

I have also submitted some documents that will be referred to in some of the following testimony.



In closing, I would like to thank each of you for holding this public hearing and allowing us to present our testimony to this committee. If you have any questions please feel free to contact me, at the office (860-953-3200, ext. 14) or via e-mail (treasurer.upffa@sbcglobal.net).

Sincerely,

Dominic M. Cutaia  
Chairman, UPFFA of CT Legislative Committee

# Cancer Risk Among Firefighters: A Review and Meta-analysis of 32 Studies

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**Objective:** The objective of this study was to review 32 studies on firefighters and to quantitatively and qualitatively determine the cancer risk using a meta-analysis. **Methods:** A comprehensive search of computerized databases and bibliographies from identified articles was performed. Three criteria used to assess the probable, possible, or unlikely risk for 21 cancers included pattern of meta-relative risks, study type, and heterogeneity testing. **Results:** The findings indicated that firefighters had a probable cancer risk for multiple myeloma with a summary risk estimate (SRE) of 1.53 and 95% confidence interval (CI) of 1.21–1.94, non-Hodgkin lymphoma (SRE = 1.51, 95% CI = 1.31–1.73), and prostate (SRE = 1.28; 95% CI = 1.15–1.43). Testicular cancer was upgraded to probable because it had the highest summary risk estimate (SRE = 2.02; 95% CI = 1.30–3.13). Eight additional cancers were listed as having a “possible” association with firefighting. **Conclusions:** Our results confirm previous findings of an elevated metarerelative risk for multiple myeloma among firefighters. In addition, a probable association with non-Hodgkin lymphoma, prostate, and testicular cancer was demonstrated. (J Occup Environ Med. 2006;48:1189–1202)

During the course of their work, firefighters are exposed to harmful substances at the fire scene as well as at the firehouse. At the fire scene, firefighters are potentially exposed to various mixtures of particulates, gases, mists, fumes of an organic and/or inorganic nature, and the resultant pyrolysis products.<sup>1,2</sup> Specific potential exposures include metals such as lead, antimony, cadmium, uranium, chemical substances, including acrolein, benzene, methylene chloride, polycyclic aromatic hydrocarbons, perchlorethylene, toluene, trichloroethylene, trichlorophenol, xylene, formaldehydes, minerals such as asbestos, crystalline, and noncrystalline silica, silicates, and various gases that may have acute, toxic effects.<sup>1,2</sup> In some situations, respiratory protection equipment may be inadequate or not felt to be needed resulting in unrecognized exposure.<sup>3</sup> At the firehouse where firefighters spend long hours, exposures may occur to complex mixtures that comprise diesel exhaust, particularly if trucks are run in closed houses without adequate outside venting. In light of the World Trade Center disaster, concerns have reemerged and heightened related to building debris particle exposures from pulverized cement and glass, fiberglass, asbestos, silica, heavy metals, soot, and/or organic products of combustion.<sup>3</sup>

To date, only one meta-analysis conducted by Howe and Burch in 1990 examined the extent of cancer risk among firefighters in 11 mortality studies.<sup>4</sup> They reported that there was an increased association with the occurrence of brain tumors, malignant melanoma, and multiple myeloma with the evidence in favor of

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causality somewhat greater for brain tumors and multiple myeloma. Since then, there have been numerous mortality and incidence studies. Hence, the purpose of this study was two-fold. The first purpose was to update the Howe and Burch findings by reviewing the methodologic characteristics of these studies and determining the probability of cancer by assessing the weight of evidence, including the calculated metarisk estimates. The second purpose was to describe a methodology for use in a meta-analysis when diverse investigations are being evaluated and summarized.

data were extracted from each article by one reviewer and was verified by another. Discrepancies identified by the second reviewer were resolved in a consensus meeting.

**Likelihood of Cancer Risk.** Statistically significant increases in cancer risks among firefighters were evaluated as the likelihood for cancer risk given a three-criteria assessment. The three criteria included "pattern of meta-relative risk association," "study type," and "consistency" among studies. These criteria were particularly important given the different methodologies used for evaluating cancer risk

(ie, SMR, PMR, RR, SIR, and OR). These criteria were used in a forward approach as illustrated in Figure 1 in which at each stage, a new criterion was applied, and the probability of cancer risk was reassessed. The likelihood for cancer risk was given an assignment of "probable," "possible," or "not likely" patterned after the International Agency for Research on Cancer (IARC) risk assessment of human carcinogenicity in terms of weight of the evidence.<sup>5</sup>

The "pattern of metarelative risk associations" was the first criterion and included a two-step evaluation. For the

**Materials and Methods**

**Search Strategy and Inclusion Criteria**

Standardized mortality ratio (SMR), proportional mortality ratio (PMR), relative risk (RR), standardized incidence ratio (SIR), and case-control/mortality odds ratio (OR) studies related to firefighters and cancer risk were evaluated. For publication selection, at least 1 year in service as firefighters was required except for those studies basing employment on death certificates. Publications were retrieved by a search of computerized databases, including Medline (1966–December 2003), Health and Safety Science Abstracts (since 1980–December 2003), Cancerlit (1963–December 2003), NIOSHTIC and NIOSHTIC2 (up to December 2003), BIOSIS Previews (1980–December 2003), and PubMed (up to December 2003) using the following key words: firefighters, fire fighters, cancer. In addition to the computerized search, bibliographies in identified papers were reviewed for additional studies.

The search was restricted to reports published in English; abstracts and reviews were not included. Studies were excluded without basic data (eg, confidence intervals) that are necessary in the derivation of the meta-analysis risk estimate. If there was more than one article with the same or overlapping population, preference was given to the article providing more comprehensive information. The

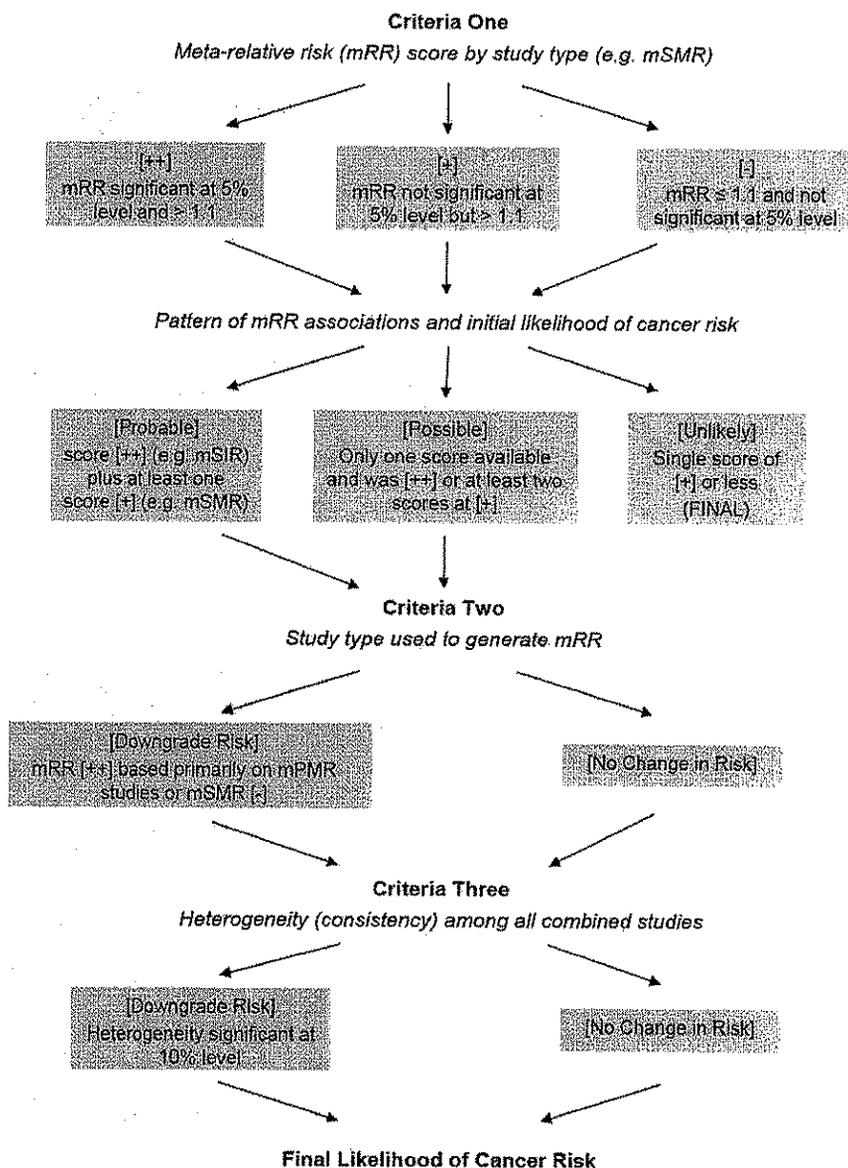


Fig. 1. Likelihood of cancer risk.

first step, the strength of the meta-analysis by each study type (eg, SMR, PMR) was assigned a score. The score of “++” was assigned if the metarelativ risk was statistically significant and greater than 1.1. The score of “+” was assigned if the metarelativ risk was not statistically significant, but the point risk estimate was greater than 1.1. The score of “-” was assigned if the metarelativ risk was not statistically significant, and the point risk estimate was equal to or less than 1.1. At the second step, these scores were used to assign a probable, possible, or unlikely designation for the pattern of metarelativ risk association. A “probable” was assigned to the cancer-specific site if one metarelativ risk (ie, mSMR, mPMR, mSMR and PMR, mRR, mSIR, mOR) was statistically significant (score of ++) and at least another was greater than 1.1 (score of +). A “possible” assignment was given if only one metarelativ risk was available and was statistically significant (score of ++) or if at least two metarelativ risks were greater than 1.1 but were not statistically significant (score of +). “Not likely” was assigned if the cancer-specific site did not meet the probable or possible criteria.

The second criterion examined the “study type” used to generate metarelativ risks. If the metarelativ risk estimate reached statistical significance (score of ++), based primarily on PMR studies, the level was downgraded. PMR studies do not measure the risk of death or death rates but rather the relative frequency of that particular cause among all causes of death. Hence, the limitation of a PMR study is that the estimate may be abnormally low or high based on the overall increase or decrease in mortality and not due to the cause of interest.<sup>6</sup> Also, if the mSMR point risk estimate was not significant and  $\leq 1.1$  (-), the level was downgraded. The third criterion used for generating the likelihood of cancer risk was an assessment of “inconsistency” among studies. Heterogeneity testing as described in statistical methods was used to evaluate

inconsistency. The level was downgraded if heterogeneity (inconsistency) testing among all combined studies had an  $\alpha \leq 0.10$ .

### Statistical Methods

For all cancer outcomes having two or more studies, the observed and expected values from each study were summed and a metarelativ risk estimate (mRR) was calculated. An mRR was calculated for each cancer by each study type, eg, SMR studies and as a summary metarelativ risk across all study types. The mRR was defined as the ratio of the total number of observed deaths or incident cases to the total number of expected deaths or incident cases as follows:

$$mRR = \frac{\sum_{i=1}^n O_i}{\sum_{i=1}^n E_i}$$

where  $O_i$  denotes observed deaths (cases) in each individual study,  $E_i$  denotes expected deaths (cases), and  $n$  is the total number of studies.<sup>7</sup> The 95% confidence interval (CI) of mRR may be computed using the Poisson probability distribution as described by Breslow and Day.<sup>8</sup> The standard error (SE) for the metarelativ risk is calculated as  $SE = \frac{1}{\sqrt{\sum W_i}}$  where  $W_i$  is the statistical weight for a given study defined as  $1/SE_i^2$  and  $SE_i$  is the standard error for a given study.

In the absence of heterogeneity, the fixed-effect model was applied for deriving the metarelativ risk estimate; otherwise, the random-effects model was used. A test for heterogeneity for the fixed-effect approach is given by  $Q = \sum_{i=1}^n W_i * \{\log(RR_i) - \log(mRR)\}^2$  where  $RR_i$  and  $mRR$  are the relative risk and the metarelativ risk, respectively. The hypothesis of homogeneity among studies would be rejected if  $Q$  exceeds  $\chi_{n-1, \alpha}^2$ . Then the random-effects model was used with a different study weight ( $W_i^*$ ) that further accounts for the interstudy variation in

effect size.<sup>8</sup> The weighing factor  $W_i^*$  in the DerSimonian and Laird random-effects model is

$$W_i^* = \frac{1}{\left[ D + \left( \frac{1}{W_i} \right) \right]}$$

where  $W_i$  is the statistical weight for a given study for the fixed-effect model and is equal to  $1/SE_i^2$  with  $SE_i$  being the standard error for a given study according to Chen and Seaton<sup>9</sup>

$$D = \frac{[Q - (n - 1)] * \sum_{i=1}^n W_i}{\left( \sum_{i=1}^n W_i \right)^2 - \sum_{i=1}^n W_i^2}$$

It should be noted that  $D$  is set to 0 if  $Q < n - 1$ . The random-effects model was validated against data provided in Petitti,<sup>10</sup> which after application using our equations gave identical results. For this study, an  $\alpha \leq 10\%$  or less for declaring heterogeneity was adopted.<sup>11</sup>

The SAS software was used to perform the calculations and validated our program for the fixed-effect model using data from different studies compiled by Howe and Burch<sup>4</sup> on standardized mortality ratios and proportional mortality ratios among firefighters. Where there were no observed deaths or incident cases, the lower confidence interval for an individual study was set at 0.1 as suggested in the method used by Collins and Acquavella.<sup>12</sup> This method was compared with the data excluding studies with a zero relative risk, and the results were similar.

## Results

### Identification and Characteristics of Studies

The computerized literature search identified 21 U.S. and 14 non-U.S. articles.<sup>13-47</sup> It was determined that three studies were not eligible for the meta-analysis because of either insufficient data,<sup>41</sup> data were combined for firefighters and other personnel,<sup>42</sup> or

the text was not published in English.<sup>43</sup> In addition, four studies<sup>44–47</sup> were excluded because of overlapping populations with other reports.<sup>18,30</sup> For example, in 1992, Demers et al<sup>18</sup> reported more observed and expected cancers than in the 1994 article.<sup>46</sup> Four additional studies<sup>48–51</sup> were identified in the review by Howe and Burch<sup>4</sup> and used in the meta-analysis. These latter four studies are not presented in Table 1. Hence, a total of 28 studies received a detailed review as shown in Table 1, which describes the study design characteristics, exposure, and outcome definitions. Sixteen were U.S. studies and 12 were non-U.S. investigations. Five studies had an internal comparison group with the remaining using regional or national comparison groups. Fourteen ascertained exposures from employment records and defined exposure as a dichotomous (yes/no) variable. The majority of the studies relied on death certificates for assessing a cancer diagnosis. Of a total of 32 articles, 26 are included in the meta-analysis as shown in Table 2. The six additional articles are case-control/mortality odds ratio studies and presented in Table 3 with one meta-analysis for non-Hodgkin's lymphoma.

### Overview of Meta-analysis

Table 2 summarizes the meta-analysis results by study type. Studies were mostly mortality and were analyzed using SMRs and PMRs. All-cause mortality had an SMR 10% less than general population rates. Mortality from all cancers was similar to the general population using SMR and RR indices, but PMR studies showed a 10% significantly higher rate (Table 2). For individual cancers, there were statistically significant elevated meta-SMR estimates for colon cancer (1.34) and multiple myeloma (1.69). PMR studies demonstrated three significantly elevated meta-PMR values that included skin (1.69), malignant melanoma (2.25), and multiple myeloma (1.42). There was one significantly elevated metarelative risk for esoph-

ageal cancer (2.03). Incidence studies showed significant meta-SIR for cancers of the stomach (1.58), prostate (1.29), and testis (1.83).

As shown in Table 3, only one cancer type, non-Hodgkin lymphoma, had two mortality OR analyses, and both were significant. The estimated mOR was essentially based on Ma et al<sup>14</sup> due to the much larger sample size of firefighters ( $n = 4800$ ) compared with 23 for Figgs et al.<sup>15</sup> Odds ratios were significantly higher for buccal cavity/pharynx (5.90) and Hodgkin's disease (2.4)<sup>14</sup> as well as the single incidence study related to bladder cancer (2.11) and non-Hodgkin's lymphoma (3.27).<sup>22</sup>

The next step was to determine the likelihood of cancer risk based on the three criteria assessment. Cancers receiving "probable" and "possible" designations are shown in Table 4. Based on evaluating the first criterion "pattern of metarelative risk" for the 20 cancer sites, eight were designated as "probable," four as "possible," and eight as an unlikely risk. Based on the second criteria "study type" stomach, rectum, skin cancer, and malignant melanoma risk were downgraded because of reliance on PMR studies for statistical significance or the mSMR point risk estimate was not significant and  $\leq 1.1$ .

For the third criterion, "inconsistency" among all studies caused a downgrading for only colon cancer to "possible." This inconsistency may have been related to several factors, including study type and a cohort effect. There were 14 SMR and PMR colon cancer studies with elevated meta-risk estimates of 1.34 and 1.25, respectively (Table 2). Of these 14 studies, there were 11 (78.6%) with firefighters employed on or before 1950. In contrast, there were six mRR and SIR studies with meta-risk estimates of 0.91 and 0.90, respectively, with half employed on or before 1950. It is possible that the older cohorts had higher exposures due to a lack of aware-

ness of the hazards or use of protective equipment.

A final check on the three criteria assessment presented in Table 4 was made by calculating an overall summary of cancer risk across all studies (ie, SMR, PMR, RR, SIR, OR). There was agreement that cancer was unlikely between the criteria assessment and the not significant summary risk estimates for esophagus, liver, pancreas, larynx, lung, bladder, kidney, and Hodgkin's disease and all cancers (Table 5). Differences between the two approaches were found for cancers of the buccal cavity/pharynx and leukemia because these were designated as possible by the criteria assessment but as not significant in the summary risk estimate. The remaining cancers were all rated as probable or possible and all had significant summary risk estimates. Of note, testicular cancer received the highest summary risk estimate (OR = 2.02; 95% CI = 1.30–3.13) related to the SIR studies compared with the "possible" designation by the three criteria assessment.

### Discussion

The meta-analysis and criteria assessment designate the likelihood of cancer among firefighters as probable for multiple myeloma and prostate cancer. Thus, the findings related to multiple myeloma are in agreement with Howe and Burch.<sup>4</sup> The Philadelphia firefighter study<sup>13</sup> was the largest cohort study reported to date investigating exposure-response relationships. For Philadelphia firefighters, the SMR results for multiple myeloma demonstrated an increasing trend with duration of employment as a firefighter: 0.73 (95% CI = 0.10–5.17) for under 9 years, 1.50 (95% CI = 0.48–4.66) for 10 to 19 years, and 2.31 (95% CI = 1.04–5.16) with six observed deaths for greater than 20 years. Except for race, there are essentially no known risk factors for multiple myeloma other than occupational exposures (eg, paints, herbicides, insecticides,

T1

T2

T3

T5

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Reference	Company Location	Design/Analysis	Study Period	Number of Workers	Comparison Group	Exposure Variable	Exposure Source	Cancer Source	Cofactors
Baris, 2001 <sup>13</sup>	Philadelphia	Cohort mortality (SMR)	1925-1986	7789	INT/NGP/NED	1, 3, 5	ER	DC	Age
Ma, 1998 <sup>14</sup>	24 US states	Case-control (MOR)	1984-1993	6607	INT	4	DC	DC	Age/race
Figgs, 1995 <sup>15</sup>	24 US states	Case-control (MOR)	1984-1989	23890 (cases) 119,450 (controls)	RGP	4	DC	DC	Age
Burnett, 1994 <sup>16</sup>	27 US states	PMR	1984-1990	5744	INT	4	DC	DC	Age
Demers, 1993 <sup>17</sup>	4 US states	Case-control (OR)	1977-1981	692 (cases) 1683 (controls)	LGP	4	TRV	TRV	Age
Demers, 1992a <sup>18</sup>	Seattle, Tacoma (WA)	Cohort mortality (SMR)	1944-1979	4528	LGP	4	ER	DCN, TRV	Age
Demers, 1992b <sup>19</sup>	Seattle, Tacoma, WA Portland	Incidence (SIR) Cohort mortality (SMR)	1944-1979	4546	INT/LW/NGP INT/LW/NGP	2, 3	ER	DCN	Age
Beaumont, 1991 <sup>20</sup>	San Francisco	Cohort mortality (RR)	1940-1970	3066	NGP	3, 6	ER	DCN	Age/yr
Grimes, 1991 <sup>21</sup>	Honolulu	PMR, RR	1969-1988	205	RGP	3, 4	ER	DC	Race
Sama, 1990 <sup>22</sup>	Massachusetts	Case-control (MOR)	1982-1986	315	LW/RGP	4, 7	TRV	TR	Age/smoke
Vena, 1987 <sup>23</sup>	Buffalo	Cohort mortality (SMR)	1950-1979	1867	NGP	3	ER	DCN	Age/yr
Feuer, 1986 <sup>24</sup>	New Jersey	PMR	1974-1980	263	LW/RGP/NGP	3, 8	ER	DCN	Age
Morton, 1984 <sup>25</sup>	Portland, Vancouver	Incidence (SIR)	1963-1977	1678	RGP	4	TR	TRV	Age
Dubrow, 1983 <sup>26</sup>	British & USA	Cohort mortality (SMR)	1950-1977	—	—	4	AR	DC	None
Musk, 1978 <sup>27</sup>	US	Cohort mortality (SMR)	1915-1975	5655	RGP, NGP	4	ER	DC	Age
Berg 1975 <sup>28</sup>	US, Great Britain	Cohort mortality (SMR)	1949-1953 and 1959-1963	—	NGP	4	DC	DC	Age
Stang, 2003 <sup>29</sup>	Germany	PMR Case-control OR	1959-1997	269 (cases) 797 (controls)	RGP	4	ER	MR	Age
Bates, 2001 <sup>30</sup>	New Zealand	Cohort mortality (SMR)	1977-1995	4221	NGP	3	AR	DC, TR	Age/yr
Firth, 1996 <sup>31</sup>	New Zealand	Incidence (SIR)	1972-1984	26207	NED	4	TR	TR	Age
Deschamps 1995 <sup>32</sup>	France	Cohort mortality (SMR)	1977-1991	830	NGP	2	ER	DCN	Age
Delahunty, 1995 <sup>33</sup>	New Zealand	Case-control (RR)	1978-1986	710 (cases) 12,756 (controls)	NGP	4	TR	TR	Age/smoke
Aronson, 1994 <sup>34</sup>	Canada	Cohort mortality (SMR)	1950-1989	5414	RGP	3, 6, 7	ER	DCN	Age/yr
Tornling, 1994 <sup>35</sup>	Sweden	Cohort mortality (SMR)	1931-1983	1153	LGP	1, 3, 7	ER	DC, TR	Age/yr
Giles, 1993 <sup>36</sup>	Australia	Incidence (SIR)	1980-1989	2865	RGP	3, 6, 7	TRV	TR	Age
Guidotti, 1993 <sup>37</sup>	Canada	Cohort mortality (SMR)	1927-1987	3328	RGP	2	ER	DCN	Age/yr
Hansen, 1990 <sup>38</sup>	Denmark	Cohort mortality (SMR)	1970-1980	886	NED	4	OTH	DC	Age (Continued)

TABLE 1  
Continued

Reference	Company Location	Design/Analysis	Study Period	Number of Workers	Comparison Group	Exposure Variable	Exposure Source	Cancer Source	Cofactors
Eliopoulos, 1984 <sup>39</sup>	Australia	Cohort mortality (SMR) PMR	1939-1978	990	RGP	3	ER	DC	Age/yr
Mastromatteo, 1959 <sup>40</sup>	Canada	Cohort mortality (SMR)	1921-1953	1039	RGP	4	DC	DC	Age
<p><u>Exposure Variables</u></p> <ol style="list-style-type: none"> <li>1. Number of firefighter runs</li> <li>2. Duration of "active" duty</li> <li>3. Duration of employment overall as a firefighter</li> <li>4. Occupation (based on death certificate or tumor registry)</li> <li>5. Company type engine, ladder</li> <li>6. Time since first employment</li> <li>7. Age-specific</li> <li>8. Employment status</li> </ol>									
<p><u>Exposure or Cancer Source</u></p> <p>ER, employment records MR, medical records AR, association records DC, death certificate DCN, death certificate nosologist TR, tumor registry with no validation TRV, tumor registry (occupation) with validation from external sources OTH, other</p>									
<p><u>Design/Analysis</u></p> <p>RR, rate ratio SMR, standardized mortality/morbidity ratio MOR, mortality odds ratio OR, odds ratio PMR, proportional mortality ratio SIR, standardized incidence mortality</p>									
<p><u>Comparison Group</u></p> <p>INT = internal LW = local workers LGP = local general population RGP = regional general population NGP = national general population NED = national employment database</p>									

engine exhausts, and organic solvents).<sup>52-57</sup> Benjamin et al<sup>58</sup> reported that blacks compared with whites have at least double the risk of being diagnosed with multiple myeloma and twice the mortality rate. Race may be ruled out as a potential factor among firefighters, because cancer risk was investigated primarily for whites.

The analyses for non-Hodgkin's lymphoma were consistent across a diversity of study designs, including SMR, PMR, SIR, and OR incident/mortality studies. All showed elevated meta-risk or point estimates. The overall summary risk estimate was significantly elevated at 1.51 (95% CI = 1.31-1.73). Hence, non-Hodgkin's lymphoma is considered a probable cancer risk for firefighters. Non-Hodgkin's lymphoma is, however, several cancer types with five International Classification of Disease (ICD) codes (200, 202.0, 202.1, 202.8, 202.9). Of importance is how the definition of non-Hodgkin's lymphoma by ICD code may contribute to the variability in study findings. For example, in a study by Demers et al<sup>19</sup> comparing firefighters with police, the mortality incidence density ratio for "lymphosarcoma and reticulosarcoma" (ICD 200) was not elevated (0.81)<sup>19</sup> but was (1.40) for "other lymphatic/hematopoietic" (ICD 202, 203). Subsequent to the time period covered in this review, Ma et al<sup>59</sup> examined Florida firefighters but evaluated only one of two cancers for ICD code 200, ie, lymphosarcoma but not reticular sarcoma and found nonsignificance (SMR = 0.94). Hence, these studies demonstrate the importance of being cognizant that differences in cancer risk estimates and interpretation of risk may be influenced by outcome definition.

Results showing a probable association for prostate cancer is curious. Prostate cancer is the most common malignancy affecting men and is the second leading cause of cancer.<sup>60</sup> Risk of developing prostate cancer is associated with advancing age, black

**TABLE 2**  
Metarelative Risk Estimates and Test for Inconsistency for Mortality and Incidence\*

Disease	Number of Studies	Reference	Observed	Expected	Metarelative Risk	95% Confidence Interval	P Value Inconsistency
<b>Mortality studies</b>							
Standardized mortality ratio (SMR)							
All causes (001-999)	12	13, 19, 23, 27, 30, 32, 34	8384	9273.8	0.90	0.85-0.97	<0.00
All cancers (140-209)	13	13, 19, 23, 27, 30, 32, 34, 35, 37-40	1801	1799.9	1.00	0.93-1.08	0.02
Buccal cavity and pharynx (140-149)	5	13, 19, 32, 34, 37	34	29.8	1.14	0.79-1.60	0.84
Esophagus (150)	4	13, 19, 23, 34	17	25.1	0.68	0.39-1.08	0.62
Stomach (151)	7	13, 19, 23, 30, 34, 35, 37	75	81.3	0.92	0.73-1.16	0.72
Colon (153)	10	13, 19, 23, 26, 28, 30, 34, 35, 37, 51	252	188.3	1.34	1.01-1.79	<0.00
Rectum (154)	6	13, 19, 23, 30, 34, 35	54	40.7	1.33	1.00-1.73	0.43
Liver/gallbladder (155-156)	5	13, 19, 23, 34, 35	22	21.9	1.00	0.63-1.52	0.92
Pancreas (157)	6	13, 19, 23, 34, 35, 37	63	64.2	0.98	0.75-1.26	0.58
Larynx (161)	3	13, 19, 34	8	13.7	0.58	0.25-1.15	0.82
Lung (162)	8	13, 19, 30, 34, 35, 37, 38, 51	378	359.2	1.05	0.95-1.16	0.50
Skin (173)	3	13, 19, 37	16	15.7	1.02	0.58-1.66	0.68
Malignant melanoma (172)	2	30, 34	4	5.9	0.67	0.18-1.70	0.23
Prostate (185)	6	13, 19, 23, 34, 35, 37	104	91	1.14	0.93-1.39	0.67
Testis (186)	1	34	3	1.2	2.50	0.50-7.30	—
Bladder (188)	6	13, 19, 23, 30, 34, 37	41	33.0	1.24	0.68-2.26	0.03
Kidney (189)	6	13, 19, 23, 34, 35, 37	30	30.9	0.97	0.44-2.13	0.01
Brain and nervous system (191-192)	8	13, 19, 23, 27, 30, 34, 35, 37	64	46.1	1.39	0.94-2.06	0.07
Non-Hodgkin's lymphoma (200, 202)	3	13, 19, 34	30	20.6	1.46	0.98-2.08	0.92
Hodgkin's disease (201)	2	19, 34	4	5.1	0.78	0.21-2.01	0.59
Multiple myeloma (203)	4	13, 26, 34, 51	24	14.2	1.69	1.08-2.51	0.15
Leukemia (204-208)	2	13, 19	30	29.9	1.00	0.68-1.43	0.27
<b>Proportional mortality ratio (PMR)</b>							
All cancers (140-209)	6	16, 24, 39, 48, 49, 50	2443	2215.7	1.10	1.06-1.15	0.64
Buccal cavity and pharynx (140-149)	—	—	—	—	—	—	—
Esophagus (150)	—	—	—	—	—	—	—
Stomach (151)	—	—	—	—	—	—	—
Colon (153)	4	28, 48, 49, 50	99	79.2	1.25	0.90-1.74	0.08
Rectum (154)	1	16	37	25	1.48	1.05-2.05	—
Liver/gallbladder (155-156)	—	—	—	—	—	—	—
Pancreas (157)	—	—	—	—	—	—	—
Larynx (161)	—	—	—	—	—	—	—
Lung (162)	4	16, 48, 49, 50	773	742.1	1.04	0.88-1.23	0.04
Skin (172-173)	2	16, 24	42	24.8	1.69	1.22-2.29	0.41
Malignant melanoma (172)	2	48, 49	9	4	2.25	1.03-4.27	0.49
Prostate (185)	—	—	—	—	—	—	—

(Continued)

TABLE 2  
Continued

Disease	Number of Studies	Reference	Observed	Expected	Metarelative Risk	95% Confidence Interval	P Value Inconsistency
Testis (186)	—	—	—	—	—	—	—
Bladder (188)	1	16	37	37.4	0.99	0.70–1.37	—
Kidney (189)	1	16	53	36.8	1.44	1.08–1.89	—
Brain and nervous system (191–192)	4	16, 48, 49, 50	64	54.9	1.17	0.90–1.49	0.27
Non-Hodgkin's lymphoma (200, 202)	1	16	66	50	1.32	1.02–1.67	—
Hodgkin's disease (201)	—	—	—	—	—	—	—
Multiple myeloma (203)	4	16, 48, 49, 50	46	32.5	1.42	1.04–1.89	0.88
Leukemia (204–208)	2	16, 24	65	53.5	1.21	0.94–1.55	0.47
Relative risk (RR)							
All causes (001–999)	—	—	—	—	—	—	—
All cancers (140–209)	2	20, 21	291	295.6	0.98	0.87–1.10	0.17
Buccal cavity and Pharynx (140–149)	1	20	11	7.7	1.43	0.71–2.57	—
Esophagus (150)	1	20	12	5.9	2.03	1.05–3.57	—
Stomach (151)	2	20, 21	25	20.6	1.21	0.80–1.81	0.55
Colon (153)	2	20, 21	25	27.5	0.91	0.60–1.36	0.92
Rectum (154)	1	20	13	9	1.44	0.77–2.49	—
Liver (155–156)	—	—	—	—	—	—	—
Pancreas (157)	1	20	17	13.6	1.25	0.73–2.00	—
Larynx (161)	1	20	3	3.8	0.79	0.17–2.35	—
Lung (162)	1	20	60	71.4	0.84	0.64–1.08	—
Skin (172–173)	1	20	7	4.1	1.71	0.68–3.49	—
Malignant melanoma (172)	—	—	—	—	—	—	—
Prostate (185)	2	20, 21	19	24.3	0.78	0.13–4.82	<0.00
Testis (186)	—	—	—	—	—	—	—
Bladder (188)	—	—	—	—	—	—	—
Kidney (189)	1	20	4	5.9	0.68	0.19–1.74	—
Brain and nervous system (191–192)	2	20, 21	9	7.1	1.26	0.55–2.34	0.14
Non-Hodgkin's lymphoma (200, 202)	—	—	—	—	—	—	—
Hodgkin's disease (201)	—	—	—	—	—	—	—
Multiple myeloma (203)	—	—	—	—	—	—	—
Leukemia (204–208)	1	20	6	9.8	0.61	0.22–1.33	—
Incidence studies (SIR)							
All cancers (140–209)	3	30, 35, 36	367	366.6	1.00	0.90–1.11	0.61
Buccal cavity and pharynx (140–149)	2	18, 36	25	19.6	1.28	0.83–1.88	0.73
Esophagus (150)	2	18, 30	10	7.6	1.32	0.63–2.42	0.51
Stomach (151)	3	18, 30, 35	38	24.1	1.58	1.12–2.16	0.33
Colon (153)	4	18, 30, 35, 36†	59	65.3	0.9	0.69–1.17	0.37
Rectum (154)	3	18, 30, 35	41	36.1	1.14	0.81–1.54	0.4
Liver (155–156)	1	35	4	4.7	0.85	0.23–2.18	—
Pancreas (157)	4	18, 30, 35, 36	22	18.2	1.21	0.76–1.83	0.83
Larynx (161)	2	18, 31	13	8.3	1.57	0.17–14.51	<0.00
Lung (162)	4	18, 30, 35, 36	111	120.0	0.93	0.76–1.11	0.83
Skin (172–173)	1	35	5	3.3	1.52	0.49–3.54	—
Malignant melanoma (172)	4	18, 30, 35, 36	60	47.9	1.25	0.96–1.61	0.87
Prostate (185)	4	18, 30, 35, 36	147	114.1	1.29	1.09–1.51	0.56

(Continued)

**TABLE 2**  
Continued

Disease	Number of Studies	Reference	Observed	Expected	Metarerelative Risk	95% Confidence Interval	P Value Inconsistency
Testis (186)	2	30, 36	21	11.5	1.83	1.13–2.79	0.15
Bladder (188)	2	18, 30	31	29.9	1.04	0.70–1.47	0.67
Kidney (189)	3	18, 30, 35	11	18	0.61	0.30–1.09	0.69
Brain and nervous system (191–192)	3	18, 30, 35	19	15.4	1.23	0.74–1.93	0.84
Non-Hodgkin's lymphoma (200–202)	1	36	4	2.2	1.82	0.49–4.65	—
Hodgkin's disease (201)	—	—	—	—	—	—	—
Multiple myeloma (203)	—	—	—	—	—	—	—
Leukemia (204–208)	4	18, 25, 30, 36	18	12.9	1.4	0.82–2.21	0.36

Note. Codes of the International Classification of Causes of Death (9th Revision) in parentheses; published data for references 48–50 in Howe and Birch.<sup>4</sup>

\*Meta analysis completed only for two or more studies.

†Reference 36 is a combination of colon and rectum cancers.

**TABLE 3**  
Mortality and Incidence Studies for Case–Control/Mortality Odds Ratio Studies

Outcome	References	Odds Ratio	95% Confidence Interval
All cancers (140–209)	Mortality 14	1.10	1.10–1.20
Buccal cavity and pharynx (140–149)	Mortality 14	5.90	1.90–18.30
Esophagus (150)	Mortality 14	0.90	0.70–1.30
Stomach (151)	Mortality 14	1.20	0.90–1.60
Colon (153)	Mortality 14	1.00	0.90–1.20
Rectum (154)	Incidence 22*	1.04	0.59–1.82
	Mortality 14	1.10	0.80–1.60
Liver/gallbladder (155–156)	Incidence 22*	0.97	0.50–1.88
	Mortality 14	1.20	0.90–1.70
Pancrease (157)	Mortality 14	1.20	1.00–1.50
	Incidence 22*	3.19	0.72–14.15
Larynx (161)	Mortality 14	0.80	0.40–1.30
Lung (162)	Mortality 14	1.10	1.00–1.20
	Incidence 22*	1.30	0.84–2.03
Skin (172–173)	Mortality 14	1.00	0.50–1.90
	Mortality 14	1.40	1.00–1.90
Malignant melanoma (172)	Incidence 22*	1.38	0.60–3.19
	Mortality 14	1.20	1.00–1.30
Prostate (185)	Mortality 14	1.20	1.00–1.30
	Incidence 22*	2.11	1.07–4.14
Testis (186)	Mortality 14	1.20	0.90–1.60
	Incidence 22*	2.11	1.07–4.14
Bladder (188)	Mortality 14	1.30	1.00–1.70
	Incidence 33	4.89	2.47–8.93
Kidney (189)	Mortality 14	1.00	0.80–1.40
	Incidence 22*	1.52	0.39–5.92
Brain and nervous system (191–192)	Mortality 14	1.41	1.10–1.70
	Incidence 22*	3.27	1.19–8.98
Non-Hodgkin's lymphoma (200, 202)	Mortality 14, 15†	2.40	1.40–4.10
	Incidence 22*	1.10	0.80–1.60
Hodgkin's disease (201)	Mortality 14	1.90	0.50–9.40
	Incidence 17	1.10	0.80–1.40
Multiple myeloma (203)	Mortality 14	1.10	0.80–1.60
	Incidence 17	1.90	0.50–9.40
Leukemia (204–208)	Mortality 14	1.10	0.80–1.40
	Incidence 22*	2.67	0.62–11.54

\*Two control groups available; police rather than state employees selected as most comparable. Significance difference only for malignant melanoma when using state employees odds ratio and 95% confidence interval was 2.92 (1.70–5.03).

†Mortality odds ratio (mOR) calculated only for non-Hodgkin lymphoma as only case–control study with at least two studies. mOR estimated based primarily on larger sample in Ma et al.<sup>14</sup>

**TABLE 4**  
Likelihood of Cancer Risk Among Firefighters After Employing Pattern of Metarelativ Risk Association, Study Type, and Inconsistency Among Studies

Cancer Site	Pattern of Metarelativ Risk Association										Criteria 2			Criteria 3	
	Criteria 1										Likelihood of Cancer Risk	Study Type	Likelihood of Cancer Risk	Inconsistency	Likelihood of Cancer Risk
	mSMR	mPMR	mSMR and PMR	mRR	mSIR	mOR	Likelihood of Cancer Risk	Study Type	Likelihood of Cancer Risk	Inconsistency					
Buccal	+	NA	NC	NC	+	-	Possible	No change	Possible	No change	No change	Possible			
Stomach	-	NA	NC	+	++	-	Probable	Down one	Possible	No change	No change	Possible			
Colon	++	+	++	-	-	-	Probable	No change	Probable	No change	Down one	Possible			
Rectum	+	NC	++	NC	+	-	Probable	Down one	Possible	No change	No change	Possible			
Skin	-	++	++	NC	NC	-	Probable	Down one	Possible	No change	No change	Possible			
Malignant melanoma	-	++	-	NA	+	-	Probable	Down one	Possible	No change	No change	Possible			
Prostate	+	NA	NC	-	++	-	Probable	No change	Probable	No change	No change	Probable			
Testis	NC	NA	NC	NA	++	-	Possible	No change	Possible	No change	No change	Possible			
Brain	+	+	+	+	+	-	Possible	No change	Possible	No change	No change	Possible			
Non-Hodgkin's lymphoma	+	NC	++	NA	NC	++	Probable	No change	Probable	No change	No change	Probable			
Multiple myeloma	++	++	++	NA	NA	-	Probable	No change	Probable	No change	No change	Probable			
Leukemia	-	+	+	NC	+	-	Possible	No change	Possible	No change	No change	Possible			

**Pattern of meta-relative risk:** "++" meta-relative risk is significant at the 5% level and >1.1; "+" meta-relative risk is not significant at the 5% level but <1.1; "-" meta-relative risk is ≤1.1 and not significant at the 5% level.

NA indicates no available studies; NC, not able to calculate because only one study of that type available.

**Study type:** down one level, the meta-relative risk (++) is based primarily on mPMR studies and/or negative (-) mSMR studies.

**Inconsistency among studies:** down one level heterogeneity significant among all combined studies at the 10% level.

ethnicity, a positive family history, and may be influenced by diet. Although the positive association with prostate cancer may be due to some of these factors, it is unlikely that these entirely explain the findings; most studies analyzed white men adjusting for age. The summary risk estimate was 1.28 (95% CI = 1.15–1.43). The mSIR was significantly elevated, and all individual studies showed excess SIR values. Parent and Siemiatycki,<sup>61</sup> in a review article, concluded that there was suggestive epidemiologic evidence for prostate cancer associated with exposure to pesticides and herbicides, metallic dusts, metal working fluids, polycyclic aromatic hydrocarbon, and diesel engine emissions. Certainly firefighters are exposed to these latter two agents. Recently, exposure to complex mixture in the semiconductor industry also has been associated with an increase in prostate cancer.<sup>62</sup> Thus, it is possible that some of the mixed exposures experienced by firefighters may be prostate carcinogens. Ross and Schottenfeld<sup>63</sup> have cautioned, however, against associating occupational exposures with prostate cancer.

Although there were only four studies evaluating testicular cancer, we propose upgrading the likelihood of cancer risk from possible to probable. This upgrade is suggested because testicular cancer had the largest summary point estimate (2.02, 95% CI = 1.30–3.13) as well as consistency among the one SMR study, two incidence studies, and one case-control study showing elevated risk estimates between 1.15 and 4.30. Testicular cancer is the most common malignancy between the ages of 20 and 34. Except for cryptorchism, no risk factor has been clearly demonstrated.<sup>64</sup> Because testicular cancer occurs among younger men with high survival, mortality studies are less germane. Bates et al<sup>30</sup> showed an increase in the incident cases of testicular cancer with firefighter exposure duration as follows: 10 years:

**TABLE 5**

Summary of Likelihood of Cancer Risk and Summary Risk Estimate (95% CI) Across All Types of Studies for All Cancers

Cancer Site	Likelihood of Cancer Risk by Criteria	Summary Risk Estimate (95% CI)	Comments
Multiple myeloma	Probable	1.53 (1.21–1.94)	Consistent with mSMR and PMR (1.50, 95% CI = 1.17–1.89) Based on 10 analyses Heterogeneity—not significant at the 10% level
Non-Hodgkin lymphoma	Probable	1.51 (1.31–1.73)	Only two SMR and another PMR studies Slightly higher than mSMR and PMR (1.36, 95% CI = 1.10–1.67) Based on eight analyses Heterogeneity—not significant at the 10% level
Prostate	Probable	1.28 (1.15–1.43)	Consistent with mSIR (1.29, 95% CI = 1.09–1.51) Based on 13 analyses Heterogeneity—not significant at the 10% level
Testis	Possible	2.02 (1.30–3.13)	Slightly higher than mSIR (1.83, 95% CI = 1.13–2.79) Based on four analyses Heterogeneity—not significant at the 10% level
Skin	Possible	1.39 (1.10–1.73)	Slightly lower than mSMR and PMR (1.44, 95% CI = 1.10–1.87) – derived on basis of PMR studies Based on eight analyses Heterogeneity—not significant at the 10% level
Malignant melanoma	Possible	1.32 (1.10–1.57)	Slightly higher than mSMR and PMR (1.29, 95% CI = 0.68–2.20) Based on 10 analyses Heterogeneity—not significant at the 10% level
Brain	Possible	1.32 (1.12–1.54)	Slightly higher than mSMR and PMR (1.27, 95% CI = 0.98–1.63) Based on 19 analyses Heterogeneity—not significant at the 10% level; there was heterogeneity among SMR studies
Rectum	Possible	1.29 (1.10–1.51)	Slightly lower than mSMR and PMR (1.39, 95% CI = 1.12–1.70) Based on 13 analyses Heterogeneity—not significant at the 10% level
Buccal cavity and pharynx	Possible	1.23 (0.96–1.55)	Slightly higher than mSMR (1.18, 95% CI = 0.81–1.66) Based on nine analyses Heterogeneity—not significant at the 10% level
Stomach	Possible	1.22 (1.04–1.44)	Lower than mSIR (1.58, 95% CI = 1.12–2.16); Based on 13 analyses Heterogeneity—not significant at the 10% level
Colon	Possible	1.21 (1.03–1.41)	Slightly lower than mSMR and PMR (1.31, 95% CI = 1.08–1.59) Based on 25 analyses Heterogeneity—significant at the 10% level; there were heterogeneity among SMR and PMR studies
Leukemia	Possible	1.14 (0.98–1.31)	Similar to mSMR and PMR (1.14, 95% CI = 0.92–1.39) Based on eight analyses Heterogeneity—not significant at the 10% level
Larynx	Unlikely	1.22 (0.87–1.70)	Higher than mSMR (0.58, 95% CI = 0.25–1.15) Based on seven analyses Heterogeneity—not significant at the 10% level
Bladder	Unlikely	1.20 (0.97–1.48)	Similar to mSMR and PMR (1.24, 95% CI = 0.83, 1.49) Based on 11 analyses Heterogeneity—significant at the 10% level; there was heterogeneity among SMR studies
Esophagus	Unlikely	1.16 (0.86–1.57)	Higher than mSMR (0.68, 95% CI = 0.39–1.08) Based on eight analyses Heterogeneity—not significant at the 10% level
Pancreas	Unlikely	1.10 (0.91–1.34)	Slightly higher than mSMR (0.98, 95% CI = 0.75–1.26) Based on 13 analyses Heterogeneity—not significant at the 10% level
Kidney	Unlikely	1.07 (0.78–1.46)	Similar to mSMR and PMR (1.23, 95% CI = 0.94–1.59) Based on 12 analyses Heterogeneity—significant at the 10% level; there was heterogeneity among SMR studies

(Continued)

TABLE 5  
Continued

Cancer Site	Likelihood of Cancer Risk by Criteria	Summary Risk Estimate (95% CI)	Comments
Hodgkin's disease	Unlikely	1.07 (0.59–1.92)	Higher than mSMR (0.78, 95% CI = 0.21–2.01) Based on three analyses Heterogeneity—not significant at the 10% level
Liver	Unlikely	1.04 (0.72–1.49)	Similar to mSMR (1.00, 95% CI = 0.63–1.52) Based on seven analyses Heterogeneity—not significant at the 10% level
Lung	Unlikely	1.03 (0.97–1.08)	Similar to mSMR and PMR (1.05, 95% CI = 0.96–1.14) Based on 19 analyses Heterogeneity—not significant at the 10% level; there was heterogeneity among PMR studies
All cancers	Unlikely	1.05 (1.00–1.09)	Similar to mSMR and PMR (1.06, 95% CI = 1.02–1.10) Based on 25 analyses Heterogeneity—significant at the 10% level; there was heterogeneity among SMR studies

CI indicates confidence interval; SMR, standardized mortality ratio; PMR, proportional mortality ratio; SIR, standardized incidence ratio.

SIR = 1.39, 95% CI = 0.2–5.0; 11 to 20 years: SIR = 4.03, 95% CI = 1.3–9.4. In those exposed greater than 20 years, the risk estimate remained elevated but declined (SIR = 2.65, 95% CI = 0.3–9.6), possibly because testicular cancer generally occurs at a younger age. Bates et al<sup>30</sup> argued that, although the reason for the excess risk of testicular cancer remained obscure, the possibility that this is a chance finding was low because incident studies are likely the most appropriate methodology for a cancer that can be successfully treated.

The 1990 findings of Howe and Burch<sup>4</sup> showing a positive association with brain cancer and malignant melanoma are compatible with our results because both had significant summary risk estimates. Brain cancers were initially scored as probable but then downgraded to possible (Table 5). There was inconsistency among the SMR studies, which resulted in the use of the random-effects model, yielding confidence limits that were not significant (SMR = 1.39, 95% CI = 0.94–2.06) (Table 2). This inconsistency primarily resulted from the Baris et al study,<sup>13</sup> a 61-year follow up of 7789 firefighters demonstrating a marked reduction in brain cancer (SMR = 0.61, 95% CI = 0.31–1.22). As

noted in Table 4, however, there were elevated, but not significant, risk estimates across all studies, ie, mSMR, mPMR, mRR, and mSIR. This consistency is all the more remarkable given the diversity of rare cancers included in the category “brain and nervous system.” Furthermore, there was a 2003 study by Krishnan et al<sup>65</sup> published after our search that examined adult gliomas in the San Francisco Bay area of men in 35 occupational groups. This study showed that male firefighters (six cases and one control) had the highest risk with an odds ratio of 5.93, although the confidence intervals were wide and not significant. In addition, malignant melanoma was also initially scored as probable but was downgraded to “possible” due to study type. This study downgrade was related to the negative SMR (–) and reliance primarily on a PMR study. Thus, in conclusion, our study supports a probable risk for multiple myeloma, similar to Howe and Burch’s<sup>4</sup> findings, and a possible association with malignant melanoma and brain cancer.

### Summary

We implemented a qualitative three-criteria assessment in addition to the quantitative meta-analyses. Based on the more traditional quan-

titative summary risk estimates shown in Table 5, 10 cancers, or half, were significantly associated with firefighting after the three cancers were designated as a probable risk based on the quantitative meta-risk estimates and our three criteria assessment. These cancers included multiple myeloma, non-Hodgkin’s lymphoma, and prostate. A recommendation is also made, however, for upgrading testicular cancer to “probable” based on the twofold excess summary risk estimate and the consistency among the studies. Thus, firefighter risk for these four cancers may be related to the direct effect associated with exposures to complex mixtures, the routes of delivery to target organs, and the indirect effects associated with modulation of biochemical or physiologic pathways. In anecdotal conversations with firefighters, they report that their skin, including the groin area, is frequently covered with “black soot.” It is noteworthy that testicular cancer had the highest summary risk estimate (2.02) and skin cancer had a summary risk estimate (1.39) higher than prostate (1.28). Certainly, Edelman et al<sup>3</sup> at the World Trade Center, although under extreme conditions, revealed the hazards that firefighters may encounter only because air monitoring was performed.

As noted in Table 1, approximately half of the studies used local, regional, or national general population rates as the comparison group. These general population comparison groups raise concern that the actual risk of cancer may be underestimated due to the healthy worker effect related to the strict physical entry requirements, maintenance of better physical fitness, and good health benefits. The healthy worker bias may be less pronounced, however, for cancer than for conditions such as coronary heart disease. Furthermore, tobacco is unlikely a contributing factor because cancers known to be associated with smoking such as lung, bladder, and larynx were designated as unlikely and corresponding summary risk estimates were not statistically significant.

These findings of an association of firefighting with significant increased risk for specific types of cancer raise red flags and should encourage further development of innovative comfortable protective equipment allowing firefighters to do their jobs without compromising their health. Studies are especially needed that better characterize the type and extent of exposures to firefighters.

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## Uniformed Professional Fire Fighters Association of Connecticut



### IARC

The International Agency for Research on Cancer (IARC) is a component of the World Health Organization (WHO). The main activity of the IARC consists of evaluation of potential human carcinogens and publication of the IARC Monographs series. The IARC classification is considered the gold standard reference for carcinogens.

### Classification and Regulation of Carcinogens

Studies of carcinogens may report differing observations, such as stronger or weaker associations between a carcinogen and a specific disease, and may even yield conflicting results. International and federal agencies review available data and assign a different weight to each study of carcinogens (the weight-of-evidence approach). This classification strategy is widely accepted and used to assess the carcinogenic risk of a chemical to humans. Scientific studies cannot perfectly duplicate nature, and there are many individual differences in susceptibility to cancer, so there are no absolute answers to questions of cancer causation. The classifications below reflect the confidence of the scientific community in the available studies. Classifications are updated as the body of current scientific knowledge grows.

### IARC Classification

The International Agency for Research on Cancer (IARC) evaluates chemicals, manufacturing processes, and occupational exposures for carcinogenic potential. IARC monographs (reports) contain evaluations of specific chemicals or processes.

The IARC uses the following classification system.

**Group 1** - The agent is carcinogenic to humans. This category is used only when there is sufficient evidence of carcinogenicity in humans.

**Group 2A** - The agent is probably carcinogenic to humans. This category is used when there is limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals. However, an agent may be classified in this category solely on the basis of limited evidence of carcinogenicity in humans or of sufficient evidence of carcinogenicity in experimental animals strengthened by

supporting evidence from other relevant data.

**Group 2B** - The agent is possibly carcinogenic to humans. This category is generally used for agents for which there are limited evidence in humans in the absence of sufficient evidence in experimental animals. It may also be used when there is inadequate evidence of carcinogenicity in humans or when human data are nonexistent but there is sufficient evidence of carcinogenicity in experimental animals.

**Group 3** - The agent is not classifiable as to its carcinogenicity to humans. Agents are placed in this category when they do not fall into any other group.

**Group 4** - The agent is probably not carcinogenic in humans. This category is used for agents for which there are evidence suggesting lack of carcinogenicity in humans as well as evidence suggesting lack of carcinogenicity in experimental animals.

Table 1 shows examples of chemicals in each of the classification groups.

**Table 1. IARC Classification**

Group	Evidence	Examples
1	Sufficient (human)	Arsenic, aflatoxin, benzene, estrogens, vinyl chloride
2A	Limited (human) Sufficient (animal)	Benz (a) anthracene, diethylnitrosamine (DEN), polychlorinated biphenyls(PCB), styrene oxide
2B	Limited (human) Inadequate (human) Sufficient (animal)	TCDD, styrene, urethane
3	Inadequate (human)	5-azacytidine, diazepam
4	Inadequate (animal)	Caprolactam

September 15, 2000

The Honorable Donna Shalala  
Secretary of Health and Human Services  
U.S. Department of Health and Human Services  
200 Independence Avenue, S.W.  
Washington, D.C. 20201

Dear Secretary Shalala,

On behalf of the more than 240,000 members of the International Association of Fire Fighters, we strongly object to the conclusions and recommendations of a recent MMWR article about Hepatitis C virus infection among emergency responders (MMWR 49(29); 660-5, July 28,2000). We believe that the CDC's conclusion that emergency response personnel are not at increased risk for Hepatitis C infection is scientifically flawed. Moreover, their recommendation that emergency response personnel not receive "baseline" testing for Hepatitis C is misleading and will make it more difficult to determine when an infection is occupationally related. The CDC's position will harm many of our members by failing to identify those with the disease, thus preventing them from getting timely and appropriate counseling and treatment.

In the MMWR article, the CDC states "This report summarizes the findings of five studies of HCV infection among first responders." This statement is untrue and grossly misleading. Only two of the five "studies" contain published data and both of these efforts were developed and designed to assess issues related to Hepatitis B. The three remaining "studies" represent unpublished data collected during what were primarily Hepatitis C education and screening programs. Data collected in an uncontrolled and scientifically flawed manner can not simply be dubbed a "study" by the CDC in order to confer validity. Furthermore, these "studies" were all cross sectional voluntary studies that had limited participation rates. The "studies" collected little to no information about the participants' occupational exposures, thus severely limiting the ability to assess any occupational risk factors.

Most importantly, four of the five "studies" failed to show an association between Hepatitis C and the most common risk factors in the general population (injection drug use, high-risk sexual behavior, and transplant/transfusion prior to 1992). Despite the CDC's inability to explain the prevalence of the Hepatitis C in emergency responders, they still rejected an occupational risk factor.

Listed below are the “studies” cited by the CDC as evidence in support of their conclusions and the serious scientific flaws associated with them.

### **Philadelphia, Pennsylvania**

The CDC conducted a review of limited non-occupational data collected during a Hepatitis C screening effort that used a home medical screening test (Home Access).

- The data that the CDC received from Home Access Health Corporation reflects only a fraction of the Philadelphia fire fighters that tested positive for Hepatitis C because of serious selection bias issues. A significant number of fire fighters that had previously tested positive for Hepatitis C elected not to participate in the Home Access screening program because it was unnecessary. Our local affiliate has identified 155 Hepatitis C positive fire fighters, a great deal more than the 64 that the CDC acknowledges. Additionally, our local affiliate is aware of many more Hepatitis C positive fire fighters and emergency medical personnel that have chosen not to come forward for fear of repercussions from their employer. The CDC never contacted either the IAFF or our local affiliate in Philadelphia to investigate and confirm these additional Hepatitis C positive members. The Home Access screening process was initiated only after it was discovered by our local affiliate that a number of fire fighters had contracted Hepatitis C. Our local affiliate then attempted to work with the City of Philadelphia to begin an organized Hepatitis C testing program for all current and retired fire fighters. After the City of Philadelphia failed to address these concerns, the local affiliate then advised its members to donate blood or sign-up as a bone marrow donor as a method of obtaining a Hepatitis C test. This screening identified additional Hepatitis C positive fire fighters. Some fire fighters used their spouses’ health care coverage for testing and treatment in order to avoid the stigma often associated with bloodborne pathogens, including fear of losing their jobs. After this second wave of Hepatitis C positive test results was discovered our local affiliate accepted the donation of the Home Access screening kits.
- The Home Access test program was not intended or designed to serve as a scientific study, but rather to provide a diagnostic service to a group of workers with occupational risk factors for Hepatitis C. Accordingly, there was no control over who received the test (e.g. the study population). Furthermore, there is no data on the percentage of people who elected to use the test. Given the poor control of the screening program population and the selection bias caused by previous Hepatitis C tests, this data is so tainted that it is impossible to draw accurate or valid conclusions about prevalence or risk.
- This “study” is the largest source of data on fire fighter’s Hepatitis C status cited in the CDC article, yet Home Access asked no questions about occupational risk factors. How could the CDC use this data to draw inferences about occupational risk factors?
- The CDC, in its analysis of the Home Access data, eliminated 33 people whom Home Access determined to be positive by EIA test but were indeterminate by subsequent RIBA testing or because there was insufficient blood for confirmatory testing. These problems are common with home screening and further illustrate why this testing mechanism was not intended for, nor appropriate to use as, a source for scientific

studies. The positive test results that were eliminated represent 20.6% of the total positive test results from the portion of fire fighters that Home Access screened. The CDC acknowledges in its editorial note that an estimated 50-80% of these positive EIA test results that were eliminated were truly positive for Hepatitis C, yet they neglected to add these Hepatitis C positive fire fighters into the study population and recalculate the prevalence rates. Although the MMWR article graphically represented the inclusion of this data (Figure 1), the CDC did not note in the body of the article that the data indicated an elevated prevalence of the disease. If the data had included the other Philadelphia fire fighters that tested positive for Hepatitis C it is likely that there would have been a statistically significant association.

### **Atlanta, Georgia**

The CDC reanalyzed stored blood that was collected in 1991 from a voluntary group of metropolitan Atlanta uniformed personnel to study Hepatitis B.

- Scientific studies that rely on volunteers are commonly tainted by selection bias since workers with a compromised health status are less likely to participate.
- The survey instrument used to collect data limited occupational exposure questions to the prior six months resulting in possible misclassification bias. While this technique is often used to counteract recall bias, it results in unique problems in an occupational setting. The "study" did not evaluate whether there were any changes in training, standard operating procedures, or protective equipment in the fire department that may have rendered the six months in question unrepresentative of the emergency responders' career experience. Furthermore, given the extremely long time that Hepatitis C may remain undetected, the six months in question may not be representative of the emergency responders' career experience due to changes in rank or function within the fire department.
- The "study" showed prevalence rates in the range of the national rate yet showed no association with drug use or history of blood transfusion, two of the most strongly associated risk factors in the general population. "Normal" prevalence rates in the absence of these common risk factors indicates an alternate (e.g. occupational) mechanism of exposure to Hepatitis C. Given the CDC's position that fire fighters and emergency medical personnel are at risk for bloodborne pathogens, why was the plausible occupational risk not addressed?

### **Connecticut**

The CDC reanalyzed stored blood that was collected in 1991 from a voluntary group of both volunteer and professional fire fighters in Connecticut. Blood collected for this "study" was initially intended to analyze serologic response to the Hepatitis B vaccine.

- The "study" was not intended to research risk factors for bloodborne pathogen exposures and therefore did not assess any occupational or non-occupational exposures.
- Only 68.4% of those who initially participated in the Hepatitis B vaccination program elected to submit the blood samples that were used in this reanalysis, further compounding the selection bias associated with voluntary studies.

- Furthermore, 4.5% of those who elected to participate were excluded from the “study” because they showed previous exposure to Hepatitis B. These blood samples were not used in the initial “study,” nor were they included in the subsequent reanalysis. Although Hepatitis C exposure was not tested at the time of the original “study,” it is very possible that some of those excluded also had Hepatitis C since many risk factors are associated with both diseases.
- More than twenty six percent of the “study” population included volunteer fire fighters. In general, volunteer fire fighters are not as likely to be exposed to the occupational risk factors for Hepatitis C since their service as fire fighters is incidental to their full time employment. The effect of including volunteer fire fighters would tend to diminish any true occupational risk factors.

### **Miami-Dade County, Florida**

The Miami-Dade Fire Rescue Department and our local affiliate conducted a Hepatitis C education and voluntary screening program for its members utilizing Hepatitis-C Alert, Inc.

- The program was a voluntary screening for Hepatitis C and not an epidemiologic study. The results are subject to selection bias because some of those who chose not to participate may have already know that they had Hepatitis C and therefore there was no need to participate.
- Despite selection bias, 0.7% of those who filled out the questionnaire self-reported that they were Hepatitis C positive. These people did not provide a blood sample and thus their data was not analyzed. The CDC did not include this additional 0.7% in their analysis of the Miami-Dade data, nor did they mention this fact in the MMWR article’s editorial note.
- The CDC concluded that Hepatitis C infection was not associated with occupational exposure despite the fact that 81% of those who tested positive reported some level of exposure to blood or body fluids and 59.4% reported greater than 8 exposures. This information was not included in MMWR article, nor do we have data on exposures among those without Hepatitis C. The lack of variability in the data may make it impossible to determine whether there is an association between occupational exposure to blood and Hepatitis C through the simple statistical analysis conducted by the CDC. However, other statistical tools, such as logarithmic transformation of the data may be necessary before normal analytic tests can be performed. Unfortunately the CDC failed to include the univariant analysis, power calculation, risk ratios or confidence intervals for much of the MMWR article thus preventing us from more fully responding to this data.

### **Pittsburgh, Pennsylvania**

Researchers studied the prevalence of Hepatitis C in emergency medical personnel working in an urban EMS system.

- Since the program was voluntary and the purpose was Hepatitis C screening, the results are subject to selection bias in that those who chose not to participate may have already known that they had Hepatitis C.

- The CDC concluded that Hepatitis C infection was not associated with occupational exposure despite the fact that 80% of those with Hepatitis C reported significant blood or body fluid exposures during their careers. Unfortunately the CDC failed to include the univariate analysis, power calculation, risk ratios or confidence intervals from much of the MMWR article thus preventing us from more fully responding to this data.

There are several factors that the CDC should have been considered before making such unfounded assertions based upon data of such poor quality. Such factors are:

*Selection bias:* What is the impact of selection bias when a fire fighter has already been diagnosed with Hepatitis C and declines to participate in subsequent screening tests? What is the impact of selection bias in voluntary studies when the results of the test can have severe implications for worker's compensation coverage of medical claims, potential to lose one's job, and the stigma often associated with bloodborne pathogens?

*Healthy worker effect:* Fire fighters are healthier as a whole than the U.S. population, with certainly less disease than compared to the general population. Epidemiologists widely recognize this type of finding as the healthy worker effect. How does the healthy worker effect impact this particular disease in this population? Would it have been more appropriate to use a subset of NHANES III data that only included working people?

*Survivor bias:* Given that unhealthy people (potentially Hepatitis C positive) may leave the fire service due to an inability to perform the rigorous job demands, is there an under-representation of occupationally acquired Hepatitis C?

*Drug screening:* Given that most public safety personnel, including emergency response employees, are drug tested (either at the time they are first hired or on a subsequent basis) they are less likely to have the most common non-occupational risk factors for Hepatitis C. Are the patterns of drug use (e.g., injection drugs vs. marijuana) different for a group of workers with rigorous physical demands and drug testing when compared to the general population?

*Prevalence versus risk:* Is it scientifically valid to equate the prevalence of a disease in a population of workers with the risk of that population acquiring the disease? How does the healthy worker effect impact this issue?

The CDC acknowledges that first responders, including fire fighters and emergency medical personnel, exposed to blood are at risk for infection by bloodborne pathogens. The exposure data from the "studies" cited indicates that emergency response employees have a high rate of exposure to blood and body fluids. However, we take great exception with the CDC's conclusion that "first responders are not at greater risk than the general

population for HCV infection” given the many problems associated with each of the “studies” in question. In light of the biological and occupational plausibility of exposure, we believe that it is impossible to make any statements about the lack of association between work as an emergency response employee and Hepatitis C using the data from the five selected “studies.”

We are also deeply concerned about the CDC’s timing of the MMWR article given that they were aware that the National Institute for Occupational Safety and Health (NIOSH) is in the process of conducting the first properly designed study focused solely on evaluating Hepatitis C in the fire service. Why was it necessary to print the MMWR article before NIOSH completed its study?

The article’s improper scientific conclusions are compounded by the recommendation against “routine” surveillance. While routine periodic testing for Hepatitis C may not be warranted, a strong argument can and should be made for baseline testing of all incumbent emergency response personnel as well as subsequent new-hires. Baseline testing will identify personnel with Hepatitis C and afford them the opportunity for timely counseling and treatment. Baseline testing will also assist in identifying personnel who subsequently develop Hepatitis C from a work-related exposure. While we agree that post-exposure testing is appropriate, it is important to recognize that emergency responders have unrecognized exposures due to the nature of their work and that there are often occupational barriers (e.g., complicated reporting procedures, social stigma, retaliation) to reporting exposures and receiving the appropriate medical care. It is also important to recognize that there are tens of thousands of emergency responders that had occupational exposures to blood early in their career that were not detected or documented because of the lack of awareness, lack of knowledge, and lack of a mechanism to report exposures. It is the position of the IAFF, as well as others in the fire and emergency services, including the International Association of Fire Chiefs, that all incumbent and newly hired employees receive a baseline Hepatitis C test and that all members also be provided with appropriate post-exposure testing, education, and treatment.

In light of the serious scientific shortcomings of this MMWR article, we demand that the CDC retract this article and issue a statement clarifying the benefits of establishing baseline data for each fire fighter. The CDC must undertake a more comprehensive review of this issue. This review should include scientists from NIOSH who have a better understanding of occupational safety and health issues and incorporate input from fire service personnel with expertise in occupational health and safety.

Finally, in 1994 the Ryan White Act was passed (Federal Register Vol. 59, No. 54 / Monday March 21, 1994. 13418-13428). This act created a mechanism by which emergency response employees can be notified about occupational exposures to infectious diseases. The list of diseases specifically excluded Hepatitis C because of “difficulty in interpretation of laboratory test, lack of routine test availability, and lack of

definitive treatment.” In the supplementary information the CDC noted that “CDC will continue to monitor the scientific literature on hepatitis C, however, and if new information becomes available that suggests that hepatitis C should be returned to the list of diseases contained here, CDC will amend the list.” There is now an accurate medical test for Hepatitis C and a treatment protocol (interferon or interferon and ribavirin). We now formally request that the CDC conduct a long overdue review of the relevant information on Hepatitis C and officially add Hepatitis C to the list of diseases covered by the Ryan White Act.

We trust that the CDC will take all steps necessary to correct these serious misstatements that have allowed employers to allow their fire fighters and emergency medical personnel to remain at risk by delaying implementation of proper baseline testing programs.

Sincerely,

Harold A. Schaitberger  
General President

cc: William Jefferson Clinton, President of the United States  
Albert Gore, Vice President of the United States  
Tom Harkin, Senator, Ranking Minority Member, Senate Labor, Health and Human Services, and Education Subcommittee  
David Obey, Congressman, Ranking Minority Member, House Labor, Health and Human Services, Education, and Related Agencies Subcommittee  
Dr. Linda Rosenstock, Director, National Institute for Occupational Safety and Health  
George Casey, President, IAFF Local 22, Philadelphia, Pennsylvania  
Joseph King, President, IAFF Local 1, Pittsburgh, Pennsylvania  
Peter Carozza, President, Uniformed Professional Fire Fighters of Connecticut  
David Rhodes, President, IAFF Local 134, Atlanta, Georgia  
Dominick Barbera, President, IAFF Local 1403, Miami-Dade County, Florida


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July 28, 2000 / 49(29);660-5

# Hepatitis C Virus Infection Among Firefighters, Emergency Medical Technicians, and Paramedics at Selected Locations, United States, 1991--2000

First responders (e.g., firefighters, emergency medical technicians [EMTs], and paramedics) are at risk of occupational exposure to bloodborne pathogens. Recently, CDC has received inquiries from state and local health departments and occupational health services about the prevalence of hepatitis C virus (HCV) infection among first responders and the need for routine HCV testing among these workers. This report summarizes the findings of several studies of HCV infection among first responders. Although some of these workers may need HCV testing in certain circumstances, this report indicates that first responders are not at greater risk than the general population for HCV infection; therefore, routine HCV testing is not warranted. First responders should continue to follow standard precautions to reduce workplace exposure to bloodborne pathogens.

## Philadelphia, Pennsylvania

During November--December 1999, Home Access Health Corporation (Hoffman Estates, Illinois)\* offered to provide specimen collection kits (Hepatitis C Check™) to 4400 active and retired members of the Philadelphia Fire Department union. Respondents telephoned a toll-free number to receive their test results and to answer questions about nonoccupational risk factors for HCV infection. According to Home Access®, serum was tested first for HCV (anti-HCV) with an enzyme immunoassay (EIA 3.0; Ortho Diagnostic Systems, Inc., Raritan, NJ). Repeatedly reactive samples were tested with a supplemental recombinant immunoblot assay (RIBA™; Abbott Laboratories, Emeryville, California). In February 2000, Home Access reported that of 2146 respondents screened positive for anti-HCV. The company indicated that this prevalence was 2.5 times higher than the average of 1.8% (Home Access Health Corporation, personal communication, 2000).

In June 2000, CDC re-analyzed serologic and questionnaire data and found that of 2136 participants, 64 tested anti-HCV--positive (Table 1). The highest prevalence (4.9%) was among men aged 40--49 years. Risk factors associated with HCV infection were a history of blood transfusion before 1992 (age-adjusted risk ratio [PR]=2.2; 95% confidence interval [CI]=1.2--4.0) and illicit drug use (age-adjusted PR=4.0; 95% CI=1.2--13.0). On the basis of CDC's analysis, the 4.5% prevalence previously reported by Home Access was obtained by classifying as positive samples that tested EIA repeatedly reactive but indeterminate by RIBA, and those that tested EIA repeatedly reactive or EIA initially reactive for which no further testing was done (Table 2).

## Atlanta, Georgia

In 1991, CDC conducted a voluntary, anonymous survey among metropolitan Atlanta uniformed fire department personnel to assess occupational and nonoccupational risk factors for hepatitis B virus (HBV) infection. In 2000, stored serum samples were tested at CDC for anti-HCV using EIA 3.0; repeatedly reactive samples

tested by RIBA 3.0. Of the 437 firefighters tested, nine (2.1%) were anti-HCV--positive ([Table 1](#)); the prevalence (4.0%) was among men aged 35--39 years. HCV infection was not associated with duration of employment as a firefighter, occupational exposures to blood, history of blood transfusion, or illicit drug use; however, HCV infection was associated with a history of a sexually transmitted disease (PR=7.4; 95% CI 3.5-15.3).

### Connecticut

In 1992, Connecticut Department of Public Health and Addiction Services collected serum samples and demographic data on a voluntary basis from first responders in various regions in Connecticut for a study of immune response to hepatitis B vaccine (2). In June 2000, stored serum samples from the 1992 study were tested anonymously at CDC for anti-HCV by EIA 3.0 and RIBA 3.0. Among 382 volunteer and professional firefighters and EMTs for whom serum samples were available, five (1.3%) tested anti-HCV--positive ([Table 1](#)); prevalence was highest (2.6%) among men aged 40--49 years.

### Miami-Dade County, Florida

During March--April 2000, Hep-C ALERT, a patient advocacy organization, collaborating with University of Pittsburgh researchers, confidentially obtained serum samples and information on occupational risk factors from Miami-Dade County municipal fire department personnel. Serum samples were tested at a commercial laboratory for anti-HCV with EIA 3.0; repeatedly reactive samples were tested for HCV RNA by transcription mediated amplification (TMA™) (Bayer Corporation, Tarrytown, New York). Of the 1314 participants, 35 (2.7%) were anti-HCV--positive on the basis of EIA testing alone, and 20 (1.5%) were confirmed positive for HCV RNA. Prevalence of anti-HCV was highest (3.7%) among men aged >50 years. Increased risk for HCV infection was associated with occupational exposures to blood, type of job (firefighter, EMT, or paramedic), or duration of employment as a first responder.

### Pittsburgh, Pennsylvania

During January--March 2000, University of Pittsburgh researchers collected serum samples and information on occupational exposures from paramedics working in Pittsburgh. Samples were tested for anti-HCV by EIA 3.0 (Abbott Laboratories, Abbott Park, Illinois) without supplemental or confirmatory testing. Five (3.2%) of 153 respondents tested anti-HCV--positive ([Table 1](#)); highest prevalence (5.2%) was among men aged 40--49 years. Anti-HCV positivity was not associated with occupational exposures to blood.

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### Editorial Note:

Data from the Third National Health and Nutrition Examination Survey (NHANES III), conducted during 1988-1994, indicated that 3.9 million (1.8%) persons living in the United States have been infected with HCV. Estimates indicate that three risk factors accounted for most infections: illicit drug use (60%), high-risk sexual behavior (15%), and blood transfusion (7%) (CDC, unpublished data, 1996; 3, 4).

Health-care workers and first responders exposed to blood in the workplace are at risk for infection by bloodborne pathogens. However, their risk for acquiring HCV infection is low because HCV is not transmitted efficiently by casual contact.

through occupational exposure (4--6). After an unintentional needlestick from an HCV-positive source, risk for HCV infection is 1.8% (range: 0--7%); transmission rarely occurs from mucous membrane exposure to blood, and no transmission has been documented from intact or nonintact skin exposures to blood (4). Among first responders, HCV infection was associated primarily with nonoccupational factors, a finding similar to that for hepatitis B virus that is transmitted at a rate 10 times higher than HCV (7).

The initial interpretation of the results from the Philadelphia study was incorrect because 20.6% of the samples classified as positive were of insufficient volume to complete testing as required by the Food and Drug Administration (FDA). Manufacturer's instructions for performing EIA for anti-HCV require initially reactive samples to be repeated in duplicate; only samples that are repeatedly reactive are considered EIA-positive. Hepatitis C Check, FDA-approved conditions for reporting a positive anti-HCV result require a repeated EIA and a positive supplemental test. Samples with insufficient volume for supplemental testing are reported as "results not available --- insufficient blood." In populations with an HCV-infection prevalence of 0--50% of EIA repeatedly reactive results may be false positives (4,8).

HCV prevalence reported in studies in subpopulations should be compared with appropriate referent groups in the general population. In NHANES III, conducted during 1988--1994, overall prevalence of HCV infection among persons of both sexes aged >5 years was 1.8% but was substantially higher (4.9%) among men aged 30--59 years (3), the group that represents most of the first responders in the five studies. Because this group has aged 20 years since NHANES III was conducted, men currently aged 40--59 years would have the highest expected prevalence of infection (Figure 1).

Because of several limitations, the five studies could not exclude the possibility that some first responders acquired HCV infection from job-related exposures. First, the small sample size and limited information about occupational (percutaneous, mucosal, or skin exposures to blood) and nonoccupational risk factors may have affected the evaluation of potential sources for infection. Second, the findings do not necessarily represent first responders in the selected locations or the United States. Third, if first responders are less likely to have nonoccupational risk factors for HCV infection than the general population, then the expected prevalence of infection among first responders might be lower.

Routine HCV testing is not recommended for populations with a low prevalence of HCV infection, including first responders, unless they have a history indicating an increased risk for infection (e.g., transfusion before injecting-drug use) (4). Testing is recommended in first responders for postexposure management after percutaneous or permucosal exposure to HCV-positive blood (4), and testing could be considered for first responders when the HCV status of the source is unknown (9). To reduce workplace exposure to bloodborne pathogens, standard precautions continue to apply; first responders should be educated about transmissible bloodborne pathogens, trained in proper safety measures, and provided with appropriate protective equipment. First responders also should be vaccinated against HBV, and informed of protocols if percutaneous or mucosal exposures to blood occur (4,10).<sup>†</sup>

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† Bloodborne pathogens, 29 CFR sect. 1910.1030 (1999).

Table 1

**TABLE 1. Type of test, demographics, type of exposure history ascertained, prevalence of antibody to hepatitis C virus (anti-HCV) among first responders in five studies — selected locations, United States, 1991–2000**

Year	Atlanta 1991	Connecticut 1992	Philadelphia 1999	Miami 2000
EIA for anti-HCV	3.0*	3.0	3.0	3.0
Supplemental test	RIBA™ 3.0†	RIBA 3.0	RIBA 3.0	TMA™§
No. participants	437	382	2,136	1,314
% male	98.6%	95.8%	98.3%	88.0%
Race				
White	49.8%	83.3%	—	82.1%
Black	48.4%	10.3%	—	14.5%
Other	1.9%	6.3%	—	3.4%
Age (yrs)				
18–29	15.8%	19.6%	4.5%	10.8%
30–49	67.4%¶	63.8%	47.3%	65.9%
≥50	16.7%**	16.7%	48.2%	23.3%
Exposure history ascertained				
Occupational†	Yes	No	No	Yes
Nonoccupational	Yes	No	Yes	No
Anti-HCV positive	2.1%	1.3%	3.0%	2.7%§§

\* Ortho Diagnostic Systems, Inc., Raritan, New Jersey; Abbott Laboratories, Abbott Park, Illinois.

† Chiron Corporation, Emeryville, California.

§ Bayer Corporation, Tarrytown, New York.

¶ Grouped as age 30–44 years.

\*\* Grouped as age ≥45 years.

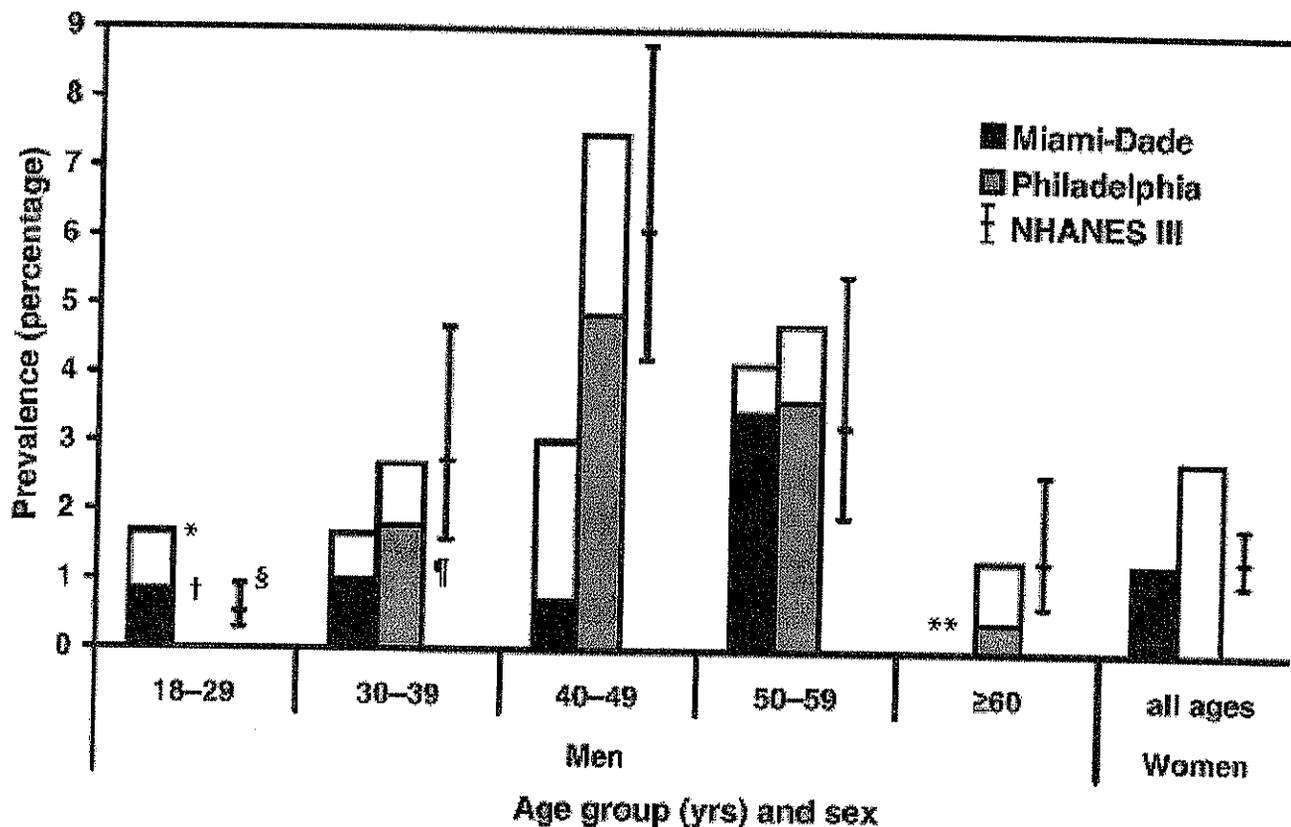
†† Needlestick, mucous membrane, and skin exposures to blood.

§§ Based on EIA results alone.

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Figure 1

**FIGURE 1. Prevalence of antibody to hepatitis C virus (anti-HCV) in first responders by age and sex — Miami-Dade County, Florida, and Philadelphia, Pennsylvania, the Third National Health and Nutrition Examination Survey (NHANES III), 1988-1994**



\* The white bars represent enzyme immunoassay (EIA) initially reactive or repeated results for which no further antibody testing was done (Miami-Dade and Philadelphia) or recombinant immunoblot assay (RIBA™) indeterminate results (Philadelphia).

† The black bars represent hepatitis C virus (HCV) RNA-confirmed positives from the Miami-Dade study. Absence of HCV RNA in a person with a positive EIA result cannot be distinguished between resolved infection, intermittent viremia, or a false positive EIA result.

‡ Sex and age-specific mean and 95% confidence interval estimated from NHANES III. Because the surveys of first responders were conducted approximately 8 years before the midpoint of NHANES III, 8 years were added to the ages of NHANES III participants when estimating the confidence intervals.

§ The gray bars represent RIBA-confirmed positives from the Philadelphia study.

\*\* In the Miami-Dade county study, prevalence could not be estimated in men aged 60-69 because of the low number of participants in this age group.

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Table 2

**TABLE 2. Results of antibody to hepatitis C virus testing of Philadelphia firefighters, by type of testing performed, 1999**

Type of Testing and Result	No.	%	Cumulative No.
EIA repeatedly reactive, RIBA™# positive	64	3.0%	64
EIA repeatedly reactive, RIBA™ indeterminate	9	0.4%	73
EIA repeatedly reactive, no confirmatory test	14	0.7%	87
EIA initially reactive, no further testing	8	0.4%	95
EIA or RIBA negative	2041	95.6%	2136
<b>Total</b>	<b>2136</b>	<b>100%</b>	

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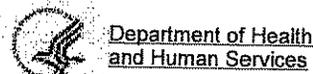
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