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# CANCER INCIDENCE AND GENERAL MORTALITY IN A COHORT OF FLORIDA FIREFIGHTERS

Principal Investigator: Lora E Fleming MD PhD MPH MSc
Co Principal Investigator: Fangchao Ma MD PhD MPH
Biostatistician: Jim Schlesselman Phd
Investigator: David Lee PhD

Dept of Epidemiology & Public Health
University of Miami School of Medicine
1801 NW 9th Ave, Suite 200
Miami, FL
33136

## Abstract

Firefighters are exposed to a complex mixture of chemical and physical hazards in the course of their work; some of these hazards have been identified as known or suspected carcinogens. Prior studies have indicated possible increased occupational risks of cardiovascular disease as well as brain, lymphopoietic, bladder, kidney, and possibly lung cancers among firefighters. Because most of the previous firefighter studies are based on mortality, the full extent of firefighters' cancer risk is not yet known. This retrospective cohort study of cancer incidence and general mortality was conducted among a group of Florida professional firefighters certified between 1972 and 1999. In addition, proportional mortality ratio (PMR) studies were performed for professional and volunteer firefighters.

A total of 1,022 cancer cases and 1,449 deaths were identified in this cohort of 35,777 male (505,612 person-years) and 2,165 female (19,866 person-years) Florida professional certified firefighters. The firefighters were consistently healthier than the general Florida population. The risk of cardiovascular, respiratory, digestive, and genitourinary diseases, external causes, overall cancer, and some site-specific cancers (such as lung cancer and buccal/pharynx cancers) was significantly decreased. Among male professional firefighters, the incidence of bladder cancer [SIR = 1.29 (95% confidence interval = 1.01-1.62)], testicular cancer [1.60 (1.20-2.09)], and thyroid cancer [1.77 (1.08-2.73)] was significantly elevated, as was thyroid cancer mortality [SMR = 4.82 (1.30-12.30)]. In a subcohort restricted to the male professional firefighters certified between 1972 and 1976, the incidence of bladder cancer [SIR = 1.49 (1.13-1.94)], colon cancer [1.47 (1.13-1.87)], prostate cancer [1.35 (1.15-1.56)], and skin cancer [1.61 (1.22-2.08)] was significantly increased. Female firefighters had mortality patterns similar to those experienced by Florida women for all diseases but atherosclerotic heart disease [SMR = 3.85 (1.66-7.58)]; elevated cancer incidence risk for kidney [SIR = 6.25 (1.26-18.3)] and thyroid [3.97 (1.45-8.65)] was also observed. Thyroid cancer incidence was also significantly increased among male Hispanic firefighters [SIR = 11.10 (2.99-28.50)].

In conclusion, this study found a significantly increased risk of thyroid, prostate, colon, and bladder cancer among male firefighters. The increase in bladder cancer risk does not appear to be related to tobacco usage. The presence of carcinogens in the firefighting environment warrants further investigation in this population.

## Summary of Key Study Findings

In general, this study found a healthy cohort of men and women who were certified as professional firefighters in Florida since 1972. These firefighters are less likely to die from a variety of cause-specific chronic diseases, including the cardiovascular, respiratory, digestive, and genitourinary diseases; they are also less likely to die from external causes, overall cancer, and some site-specific cancers, such as lung, buccal/pharynx, and pancreas cancers. However, the male professional firefighters are more likely to die from bladder cancer, and their risks are increased for cancers of the bladder, thyroid, testes, colon, prostate, and skin.

*Standardized Incidence Ratio Analyses (Cancer Only)*
The SIR analyses showed that the overall risk of cancer was significantly lower than that of the general Florida population. A reduction in risk was evident for cancers of oral cavity, stomach, lung, and brain. Significantly increased cancer incidence was observed among male firefighters for bladder, testes, and thyroid cancers.

Analyses restricted to the cohort of firefighters certified between 1972 and 1976, however, revealed that their overall risk of cancer was similar to that of the general Florida population. In this subcohort, risks for several cancer sites were significantly increased; these included bladder, colon, prostate, and skin. The risk of lung cancer was significantly lower in this subcohort relative to the general Florida population.

The SIR analyses for male Hispanic firefighters showed no significant elevation in overall cancer risk. Compared to the male Florida Hispanic population, male Hispanic firefighters had increased but not statistically significant risk for colon cancer, Hodgkin's disease, and pancreatic cancer.

Female firefighters had significantly increased overall and thyroid cancers as well as Hodgkin's disease.

*Standardized Mortality Ratio Analyses*
The SMR results showed that the overall mortality risk, the mortality risks for all non-cancer causes, and the mortality risk for infectious, allergic/endocrine, circulatory system, respiratory, digestive, and genitourinary diseases, and the mortality risk for external causes, were significantly lower in male professional firefighters as compared to male Florida population. Mortality from bladder cancer was significantly elevated in professional male firefighters. Mortality due to all cancers combined, as well as the specific cancers of oral cavity/pharynx and pancreas, were significantly decreased. There was no excess mortality due to lung cancer, brain tumors, or kidney cancer. SMR analyses restricted to professional male firefighters certified between 1972 and 1976 showed similar results.

Female firefighters had similar morality patterns to Florida women for all diseases, except atherosclerotic heart disease, which was significantly elevated.

## Usefulness of Findings

In conclusion, this study found that the significantly increased risk of bladder cancer and colon cancer in male professional firefighters is probably related to occupational exposure rather than tobacco use. A nested case-control study of bladder or colon cancer would provide a more thorough assessment of this possibility. Follow-up of this cohort for 10 or more years would allow one to better evaluate the effects of occupational firefighting exposure, provided that such follow-up is complemented by nested case-control studies. The presence of carcinogens in the firefighting environment warrants the continued use of protective equipment and further investigation of this population.

**Scientific report**

Four hypotheses were generated after a literature review of firefighter studies. These hypotheses were:

1. Overall age-adjusted cancer incidence in firefighters would be the same as compared to the general population in Florida.
2. Site-specific cancer incidence would be higher for firefighters than for the general population in Florida for one or more of the following cancers: brain, bladder, colon, kidney, skin, lung, prostate, and lymphohemotopoietic system.
3. The site-specific incident cancer risk, represented by SIRs, would be increased with increasing years of certification as a firefighter for the above-mentioned cancers.
4. Cause-specific mortality rates, such as obstructive lung disease and motor neuron disease, would be significantly higher in this cohort of Florida firefighters as compared to rates for the general Florida population.

*Overall Cancer Incidence*

Hypothesis 1 was based on previous findings that firefighters have lower or similar overall cancer incidence relative to the general population. We hypothesized that firefighters would have the same overall cancer incidence as compared to the general population. Firefighters are exposed to many known or suspected carcinogens and their risks for certain cancer sites are expected to increase, which is thought to rise enough to offset their relative lower incidence for cancer sites unrelated to firefighting because of the HWE. Our results for male professional firefighters suggest that we probably underestimated the magnitude of the HWE because the overall cancer risk in this study was significantly decreased among professional firefighters (SIR= 0.84, 95% CI = 0.79-0.90; SMR = 0.85, 95% CI = 0.77-0.94).

The HWE has been estimated to reduce the overall death rate among workers to about 70% to 80% of the rate in a reference general population (Choi, 1992). Its magnitude may be even larger in firefighters since the firefighting profession demands better fitness than most occupations. Moreover, worksite health promotion programs aimed on reducing cardiovascular and cancer risk factors among Florida firefighters have been present in some fire departments since 1984 (Zimmerman, et al., 1988), one of the targeted risk factors being obesity (Gerace, 1996). In 1989 a landmark bill requiring that new fire fighters be non-users of tobacco for at least one year prior to application was passed in the state of Florida. Since 1990 all incoming firefighters must sign an affidavit stating that they did not use any tobacco product (Gerace, 1990). These measures could have further contributed to the lowered overall cancer incidence observed in Florida male professional firefighters.

As discussed in Chapter Two, the HWE – a form of selection bias – not only occurs at the time of hire but also operates when firefighters are removed from firefighting duty. There is a continuing selection process, such that those who remain employed, that is, are survivors in the workforce, will tend to be healthier than those who leave employment (Arrighi and Hertz-Picciotto, 1994). Checkoway et al. described the HWE as comprising at least 3 factors: 1) the employment of healthy members from the source population, the healthy hire effect; 2) the survival in the industry of healthier individuals, the healthy worker survivor effect; and 3) an apparent decline in health with time-since-hire (Checkoway et al., 1989). Because of the strenuous fitness requirements for firefighting duties, all firefighter applicants must pass the physical agility exam and

undergo psychological examinations prior to hire. After the hire, firefighters are often required to have an annual medical evaluation by the fire department physician, which includes a physical examination, pulmonary function testing, audiometry, vision testing, and laboratory testing such as a complete blood count, a chemistry panel, and urinalysis; a resting electrocardiogram and a treadmill stress test are also recommended. Firefighters who fail the test will be removed from firefighting duties (Gerkin, 1995). Therefore, the HWE is likely to be very strong in firefighters, attenuating exposure effects. It is well known that the etiology of human neoplasms is complex, involving both the exposures (carcinogens and promoters) and the human body responses (DNA repair, immune monitoring, just to name a few). Because of their better fitness, firefighters may be more resistant to low-level exposures to carcinogens relative to the general population. The HWE probably was the main reason this study found a decreased overall cancer risk in professional firefighters.

*Cancer Site-Specific Incidence*

Firefighters had higher incidence for cancers of the bladder, colon, skin, and prostate listed in Hypothesis 2, although we also found increased incidence for cancer of the thyroid and testes. We did not, however, find increased risks for cancers of the brain, kidney, lung, and lymphopoietic system, which have been documented in many studies. Instead, we found that Florida firefighters had significantly lower risk for brain/CNS tumors and cancer of the lymphopoietic system and lung.

The most noteworthy findings in male professional firefighters in this study are the increased mortality (SMR = 1.79; 95% CI = 0.98-3.00) and incidence (SIR = 1.29; 95% CI = 1.01-1.62) for bladder cancer. This increase was unlikely due to smoking because other tobacco-related cancers, such as lung and oral cavity/pharynx cancer, were not increased in the cohort. Many known or suspected human bladder cancer carcinogens such as nitro polycyclic aromatic hydrocarbons (PAHs) and benzene have been found at fire scenes (Caux et al., 2002). Other occupational chemical exposures known to cause bladder cancer include aromatic amines, solvents, benzidine, coal tars and pitches, and soot and oils (Caux et al., 2002; Gustavsson et al., 1988; International Agency for Research on Cancer, 1987), substances commonly encountered by firefighters, particularly at fires in commercial establishments (Golden et al., 1995). Therefore, it is plausible that the increase in bladder cancer mortality and incidence found in male firefighters is due to their occupational exposures, a finding consistent with the majority of previous firefighters' studies. For example, Guidotti (1993) and Vena et al (1987) both reported a threefold increase in bladder cancer deaths compared to general population rates. In a retrospective cohort study among Seattle and Tacoma firefighters, bladder cancer incidence was also increased, but not statistically significant, relative to both the general population and the police. However, this finding was based on only 18 bladder incident cases and may lack statistical power (Demers et al., 1994).

Another noteworthy finding is the increase in testicular cancer (SIR = 1.60; 95% CI = 1.20-2.09) and prostate cancer (SIR = 1.49; 95% CI = 1.13-1.94) in the early cohort that consisted of professional firefighters who were relatively older and likely had the longest length of exposure. Previously, only 2 epidemiological studies have specifically addressed testicular cancer in firefighters (Giles et al., 1993; Aronson et al., 1994). Both of these prior studies were based on only 2–3 testicular cancer deaths; because both are cancers with relatively long survival, the mortality-only studies would presumably underestimate their risk. Although occupational risk factors have not been widely studied, exposures to solvents and paints have been implicated in testicular cancer

(Fleming, 1994), and testicular cancer risk should be assessed in future studies of firefighters.

Similar to the case of testicular cancer, there is no obvious carcinogenic exposure for prostate cancer that is associated with firefighting, but a 30–50% increase in prostate cancer risk has been consistently found in the majority of firefighters' studies (Beaumont et al., 1991; Golden et al., 1995). The incidence study of Seattle and Tacoma firefighters showed that firefighters' prostate cancer risk was increased relative to the general population, but that the elevation was not significant when compared to a group of police officers (Demers et al., 1994). The increase may be due to firefighters having higher screening rates for prostate cancer as a result of their increased access to health care or annual physicals.

Of particular relevance to firefighters are the higher-than-expected rates of colon and rectal cancer observed in workers with exposure to asbestos (Selikoff et al., 1968). Excesses in rectal and colon cancer have been consistently demonstrated in many studies of firefighters (Guidotti et al., 1992). One study has shown that the relative risk of colon cancer appeared to increase with duration of employment as a firefighter (Demers et al., 1994). In the present study, both mortality (SMR = 1.22; 95% CI = 0.84-1.72) and incidence risk (SIR = 1.47; 95% CI = 1.13-1.87) for colon cancer were found to be increased in the early cohort of male professional firefighters certified between 1972 and 1976; the increase in incidence risk for colon cancer was statistically significant. These findings are consistent with previous reports, suggesting that the elevation in colon cancer risk may be due to firefighting exposures.

The present study did not find the excess risks for brain tumors and lung and lymphopoietic cancer that have been documented in many previous mortality studies of firefighters. One explanation could be that our study looked at a relatively young cohort with a follow-up period insufficient to allow these cancers to emerge or the cohort may have benefited from more frequent use of protective devices as compared to the firefighters employed before 1970, among which most of previous investigations were conducted. This discrepancy with earlier studies could also due to chance, or could be the result of misclassification bias derived from using certification as a surrogate measure of firefighting exposures and/or our inability to control for confounding factors such as smoking, diet, and family history of cancer. In addition, as both lung cancer and brain tumors are divided into several histological subtypes with different underlying etiologies, lack of histological classifications for these cancers may be problematic. Unfortunately, incidence and mortality for lung cancer and brain tumors by histological diagnosis were not available; therefore firefighters' risk for these cancer subtypes could not be evaluated in the present study. Geographic differences in building materials and types of the fires fought by firefighters (e.g., forest fires, commercial fires) might have also contributed to this discrepancy. The census data for 1970, 1980, 1990, and 2000 show that Florida has experienced more rapid population growth relative to most other places in the country (http://www.census.gov), resulting in a great number of new residences being built in Florida. Modern-day building materials may produce different carcinogens during a fire compared to the materials used in previous periods. For example, the combustion of the common plastic polyvinyl chloride (PVC) has been estimated to produce dozens of different chemicals including cyanide (Baris et al., 2001), which are different from the combustion of copper piping. The chemicals produced by wood floors in a fire are also different from the chemicals generated in a vinyl flooring fire. Unfortunately, measurement of airborne exposures at fires presents formidable

technical challenges in sampling methods, equipment, and logistics (Jankovic et al., 1991).

Certain ethnic groups traditionally have been attracted into the fire service in many eastern U.S. cities such as Boston and New York (e.g., Irish and Italian Americans). Though the makeup of all big city fire departments would change in the latter years of the twentieth century as affirmative action plans were implemented to ensure that the departments would reflect the diverse composition of their communities, the Irish are still a big part of fire departments (http://allaboutirish.com/library/diaspora/ia-firefighters.htm). For example, of the 343 firefighters killed at the World Trade Center, about one third were of Irish descent (Italian-Americans come in second) (http://www.nprsucks.com/shows4.htm). Because of the differences in ethnic compositions between Florida firefighters and firefighters in other states, it is plausible that predisposition to certain cancers due to genetic and cultural differences could be partially responsible for the discrepancy with earlier studies. The HWE may be another factor. Because of the data limitations in the present study, further investigations of these cancers are warranted.

*SIRs in Relation to Duration of Certification*

Hypothesis 3 could not be tested due to data limitations. The volunteers were excluded from the SIR study because their start dates were not available. There were no exit dates for the firefighters either, which prevented us from creating internal subgroups to perform logistic or Cox regression analysis. Nevertheless, we performed SIR analyses in an early cohort of firefighters certified between 1972 and 1976 and found that the overall cancer risk in this early cohort was no longer significantly different from the general Florida population. Firefighters in the early cohort also had significant excess risk for cancers of the prostate, colon, and skin that were not shown among the entire cohort. These findings indirectly tested Hypothesis 3, suggesting a possible positive association between the cancer risk and the length of exposure.

*Non-Cancer Cause-Specific Mortality*

We found that Hypothesis 4 is incorrect (e.g., SMR for respiratory diseases = 0.50; 95% CI = 0.35-0.70). The SMR results showed that the firefighter cohort was much healthier compared to the Florida general population. The HWE might have played an important role in these results. In addition, the cohort was relatively young, with moderate years of follow-up time. The negative health effects of firefighting on the respiratory and cardiovascular system may not appear until late in life. And finally, it is possible that the increased use of the self-contained-breathing-apparatus (SCBA) in the last two decades may have protected firefighters from developing respiratory diseases.

**The Entire Scientific Report (PhD Dissertation of Co Principal Investigator, Dr Fangchao Ma) is enclosed as an Appendix.**

**Acknowledgements**

Mark Rudolph, Lydia Voti, Silvana Cobian, and Jill MacKinnon of the Florida Cancer Data System, Artie Chestnut of the Florida Fire College, Gary Sammet of the State of Florida Vital Statistics, and June Nogle of the University of Florida Bureau of Economic and Business Research.

**Publications: present and anticipated future**

Below are listed the **publications and presentations** to date based on the NIOSH funded firefighters study.

In addition to the successful completion of Dr Fangchao Ma's Dissertation for the Phd in Epidemiology at the University of Miami entitled **CANCER INCIDENCE AND GENERAL MORTALITY IN A COHORT OF FLORIDA FIREFIGHTERS,** several manuscripts are currently being developed and submitted on the cancer incidence and the general mortality studies for peer reviewed publication.

*Published Abstracts*

Ma F, Fleming LE, Lee D, Schlesselman J, Trapido E, Gerace T. Cancer Mortality among Florida Firefighters. APHA Annual Meeting, Philadelphia, PA (11/02).

Ma F, Fleming LE, Lee D, Schlesselman J, Trapido E, Gerace T. Cancer Mortality among Florida Firefighters. Society of Epidemiologic Research (SER) Annual Meeting, Palm Springs, CA (6/02).

Lee D, Dosemeci M, Fleming LE. Cancer Mortality in US Firefighters: 1984-1991, Society for Epidemiologic Research (SER), Boston, MA (poster) (6/96).

*Presentations*

11/03 Ma F, Fleming LE, Lee D, Trapido E. A Retrospective Cohort Study of General Mortality in a Cohort of Florida Firefighters. APHA Annual Meeting, San Francisco, CA, GA.

11/03 Ma F, Fleming LE, Lee D, Schlesselman J, Trapido E, Gerace T. Cancer Incidence in a Cohort of Florida Firefighters. APHA Annual Meeting, San Francisco, CA, GA.

11/03 Lee D, LeBlanc W, Lee D, Fleming LE, Gomez Marin O, Pitman T, Jane D. Acute and Chronic Disability among US Firefighters: the National Health Interview Survey (NHIS). APHA Annual Meeting, San Francisco, CA.

6/03 Ma F, Fleming LE, Lee D, Schlesselman J, Trapido E, Gerace T, Rudolph M, Voti L, Cobian S. Cancer Incidence in a Cohort of Florida Firefighters. (Poster) NAACCR, Honolulu, Hawaii.

6/03 Ma F, Fleming LE, Lee D, Schlesselman J, Trapido E, Gerace T. Mortality in a Cohort of Florida Firefighters (Poster). Society for Epidemiologic Research, Atlanta, GA.

6/03 Ma F, Fleming LE, Lee D, Schlesselman J, Trapido E, Gerace T. Cancer Incidence in a Cohort of Florida Firefighters. Society for Epidemiologic Research, Atlanta, GA.

11/02 Ma F, Fleming LE, Lee D, Schlesselman J, Trapido E, Gerace T. Cancer Mortality among Florida Firefighters. APHA Annual Meeting, Philadelphia, PA.

6/02 Ma F, Fleming LE, Lee D, Schlesselman J, Trapido E, Gerace T. Cancer Mortality among Florida Firefighters. Society of Epidemiologic Research (SER) Annual Meeting, Palm Springs, CA.

UNIVERSITY OF Miami
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**MEMORANDUM**

TO: David J. Lee, Ph.D., Epidemiology

FROM: Patricia Thomas, MPA P.T. IRB
IRB, Administrator
MSC "A"

DATE: May 14, 2003

PROTOCOL NUMBER: 95/121A

TITLE OF PROTOCOL: "Cancer Incidence and Mortality Among Florida Fire Fighters"

**APPROVAL OF FINAL REPORT: May 12, 2003**

The Medical Sciences Committee for the Protection of Human Subjects in Research has reviewed and approved the final report for the above-titled protocol.

If an investigational drug was being used, the Food and Drug Administration requires an investigator to retain study records for a period of two years following the date of the marketing application approval for the indicated drug. If no marketing application is to be filed, or if the marketing application is not approved, the file is to be retained for two years after the investigation is discontinued and the FDA is notified.

You are required to retain all records of his project for five years after its completion.

If you have any questions, please call Marilyn Fernandez at (305)-243-6494.

PT/md

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# CERTIFICATE of COURSE COMPLETION

## Lora Fleming

UM-030407767

Has successfully completed VER4.0 of the CITI Course in the Protection of Human Research Subjects on 10/7/2002 as a Catergory 6 Researcher.

| Category | Type of Research |
|---|---|
| 1 | Biomedical Research not affiliated with the VA |
| 2 | Biomedical Research affiliated with the VA |
| 3 | Social Research not affiliated with the VA |
| 4 | Social Research affiliated with the VA |
| 5 | Both Biomedical and Social Research not affiliated with the VA |
| 6 | Both Biomedical and Social Research affiliated with the VA |

THIS DOCUMENT WAS PREPARED BY
PAUL G. BRAUNSCHWEIGER Ph.D.
DIR. UM OFFICE OF RESEARCH EDUCATION
CITI COURSE SITE COORDINATOR

CONFIRMATION MAY BE OBTAINED AT
305-243-2311; CITISupport@MED.MIAMI.EDU

Paul Braunschweiger

Monday, October 07, 2002

Consult your IRB training coordinator for the Recertification/Continuing Education requirements at your institution

**Appendix**

UNIVERSITY OF MIAMI

**CANCER INCIDENCE AND GENERAL MORTALITY IN A COHORT OF FLORIDA FIREFIGHTERS**

By
Fangchao Ma, MD, MPH

A DISSERTATION

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Doctor of Philosophy

Coral Gables, Florida
June 2003

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