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CANCER INCIDENCE AND GENERAL MORTALITY IN A COHORT OF FLORIDA FIREFIGHTERS

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Cancer Incidence and General Mortality
in a Cohort of Florida Firefighters

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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.

This Dissertation is dedicated

to

my late grandmother

Su, Qixiu

for stressing the value of education and self-esteem

And also to

my parents

Dezhen Li and Mingyu Ma

for their personal sacrifices, encouragement and patience through the years

that made all of this possible

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CHAPTER ONE: EXECUTIVE SUMMARY

This chapter provides a brief introduction of background, presents the rationale and overall plan for a retrospective study of general mortality and cancer incidence in a cohort of Florida firefighters; key findings and conclusions of the study are presented.

1.1. Background

Firefighters are routinely exposed to a variety of carcinogenic substances during firefighting and its aftermath. Carcinogens such as benzene and polycyclic aromatic hydrocarbons (PAHs) have been frequently detected in fire smoke. Other carcinogens including polychlorinated dibenzofurans and dibenzo-p-dioxins, formaldehyde, metals (such as chromium and cadmium), aromatic amines, and various chlorinated hydrocarbons have also been found at fire scenes. Because of their occupational exposure to known or potential carcinogens, it has been assumed that firefighters would show an excess risk of cancer. Epidemiological studies have demonstrated increased risk for several cancers that can be plausibly linked with carcinogenic exposures encountered by firefighters in the course of their work. Although like other high-risk occupational groups, increased overall cancer risk has not been observed in most firefighter studies, substantial evidence suggests excess mortality for leukemia, non-Hodgkin's lymphoma, multiple myeloma, and cancer of the brain and bladder. Weaker but still plausible evidence links firefighting to increased risk for melanoma and cancer of the rectum, colon, stomach, prostate, and lung. Because most previous firefighter cancer studies are based on mortality data, the full extent of firefighters' cancer risk, in particular, incident cancer risk and risk for rare cancers, is not yet known. To date, only one study of cancer incidence among firefighters has been published.

1.2. Study Design and Hypotheses

This was a retrospective analysis of cancer incidence and general mortality among a cohort of state-certified Florida firefighters. Beginning in 1972, certification was required for all firefighters in Florida. A database containing 79,733 computerized professional and volunteer firefighter records from 1972 through 1998 was linked to the Florida Cancer Data System, and incident cancer cases among the cohort were identified. Vital status was determined by linking the firefighter database with the Florida Motor Vehicles database. Mortality information was obtained by linking the firefighter database with the Florida Vital Statistics database. Standardized incidence ratios and standardized mortality ratios were calculated using the general Florida population as the comparison for overall and site-specific cancers to determine whether Florida firefighters had excess risks for these cancers. The present study is the largest firefighter cancer incidence study to date. Results from this study should add to the body of knowledge concerning firefighting and incident cancer risk, particularly for low-fatality cancers that are often underestimated in mortality studies and for rare cancers that require a large cohort and long follow-up period to have sufficient cases.

The study hypotheses were:

1. Overall age-adjusted cancer incidence in firefighters would be the same compared with 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 lymphopoietic 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 compared with rates for the general Florida population.

1.3. Organizational Outline

The literature concerning the possible human health effects of occupational exposure to firefighters is summarized in Chapter Two. Included in this chapter are an extensive bibliography and a tabular summary of the results on major cancer sites from most of the epidemiological studies of firefighters.

The computerized database of all professional and volunteer firefighters was obtained from the office of the Florida Fire Marshals. Due to missing information, this database was repeatedly linked with a variety of other databases to obtain date of birth, and mortality and cancer incidence information. Cancer incidence data since 1981 were obtained by linkage with the Florida Cancer Data System (FCDS). Using linkages with the Florida Vital Statistics Records, the Florida Motor Vehicles Registry, and the Health Care Financing Administration (HCFA), date of birth and death information was added to the database. A "master study database" was constructed which listed the firefighters with their certification, date of birth, and vital status information, as well as cancer incidence and other information where applicable. The methodology and results of these linkages as well as the statistical analyses (PMR, SMR, and SIR) and rationale used in this study are described in Chapter Three. The results of analyses of both general mortality and cancer incidence are described in Chapter Four. These include the SMR, SIR, and PMR studies comparing the professional firefighters to the general Florida population; PMR analyses comparing the professional firefighters to the volunteer firefighters and comparing the volunteer firefighters to the general Florida population were also performed. Finally, the overall conclusions of the statistical analyses are discussed in Chapter Five.

1.4. Key Findings

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 major findings from retrospective analyses of cancer incidence (i.e., standardized incidence ratio analysis) and mortality (i.e., standardized mortality ratio analysis) include:

1. There is consistent evidence based on both mortality and incidence data that risk of bladder cancer was significantly increased among male professional firefighters.
2. Significant excesses in incidence and mortality for thyroid cancer were observed among male professional firefighters.
3. The incidence risk of testicular and prostate cancer was significantly increased among male professional firefighters.
4. Significantly increased incidence risk for colon and skin cancer was observed among an early cohort of male firefighters certified between 1972 and 1976.
5. Significantly increased incidence risk for kidney and thyroid cancer was observed among female professional firefighters.

6. Male Hispanic professional firefighters had significantly increased incidence for thyroid cancer.

In addition, results from the PMR analyses using the volunteer firefighters as a comparison showed that Florida professional firefighters had a significant excess mortality for colon cancer as compared to the volunteer firefighters. Bladder cancer mortality was increased, but the increase was not statistically significant.

1.5. Conclusions

The study population consists of 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 diseases, respiratory diseases, digestive diseases, 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 for cancer of the bladder, colon, and prostate are increased. The significantly increased risk of bladder and colon cancer among male firefighters does not appear to be related to tobacco use and is more likely due to their occupational exposure. The presence of carcinogens in the firefighting environment warrants continued use of protective equipment and further investigations in this population.

CHAPTER TWO: BACKGROUND

2.1. Introduction

Fire and its control have been a central issue for human society, particularly in urban communities. An estimated 1 million persons in the United States are involved in firefighting (Morse et al., 1992). Concern over the health and safety of the firefighters has increased since the second half of the 20th century. This chapter provides a brief description of the firefighter work process and a detailed review of the epidemiological and toxicological literature on the range of fire and chemical exposures and their acute and chronic health effects on firefighters.

2.2. Firefighting Work Process

Firefighters can be volunteers or professional employees of a city, township, or industrial plant. They are expected to be trained and ready to respond to a wide range of duties related to both firefighting and emergency response.

According to a work process schedule for firefighters (http://www.grand.k12.ut.us/cash/wps/FIREFGHT.htm) (International Fire Service Training Association, 1998), the firefighter controls and extinguishes fires and protects life and property by performing the following duties:

- Responds to fire alarms and other emergency calls.
- Selects hose nozzle, depending on type of fire, and directs stream of water or chemicals onto fire.
- Positions and climbs ladders to gain access to upper levels of buildings or to assist individuals from burning structures.

- Creates openings in buildings for ventilation or entrance, using ax, chisel, crowbar, electric saw, core cutter, and other power equipment.
- Protects property from water and smoke by use of waterproof salvage covers, smoke ejectors, and deodorants.
- Administers first aid and artificial respiration to injured persons and those overcome by fire and smoke.
- Maintains all firefighting and emergency response equipment.
- Communicates with superior during fire, using portable two-way radio.
- Inspects buildings for fire hazards and compliance with fire prevention ordinances.
- Performs assigned duties in maintaining apparatus, quarters, buildings, equipment, grounds, and hydrants.
- Participates in drills, demonstrations, and courses in hydraulics, pump operation and maintenance, and firefighting techniques.
- May fill fire extinguishers in institutions or industrial plants.
- May issue forms to building owners, listing fire regulation violations to be corrected.
- May drive and operate firefighting vehicles and equipment.

To perform these duties and work processes, firefighters undergo extensive preparatory and ongoing work training (Table 2.1). During the past 20 years, a trend has been established that firefighters receive cross training as emergency workers and paramedics. In addition, firefighters are expected to be in excellent physical condition during their working life. Thus, firefighters represent a group of highly motivated and highly skilled workers (Gerkin, 1995).

2.3. Occupational Exposures

Firefighters routinely face harsh and uncontrolled situations in which they are exposed to a wide array of chemicals and their pyrolysis byproducts (Table 2.2). Unlike typical industrial occupational exposures, firefighters may be exposed to many different chemicals varying from day to day and from fire to fire (Guidotti and Clough, 1992).

Occupational hazards experienced by firefighters may be categorized as thermal, chemical, psychological, and biological. The level of exposure experienced by a firefighter in a given fire depends on the materials that are burning, the combustion characteristics of the fire, the structure on fire, the presence of non-fuel chemicals, the measures taken to control the fire, the presence of victims requiring rescue, the position, or line of duty, held by the firefighter while fighting the fire, and the adequacy of protective gear. The hazards and levels of exposure experienced by the first firefighter to enter a burning building are different from those of the firefighters who enter later or who clean up after the flames are extinguished. However, the career exposure profiles of firefighters tend to average out the longer they spend in a particular rank (Lees, 1995).

There are two basic phases of firefighting: "knockdown," where the main body of fire is brought under control, and "overhaul," which involves searching for and extinguishing hidden fire. Within the last 30 years, the introduction of the self-contained breathing apparatus (SCBA) and other protective equipment has created a much safer working environment for the firefighter. In general, SCBAs are now required equipment for exposed firefighters during the "knockdown" phase of the fire; however, the SCBAs are still not normally worn during overhaul activities even though this stage may also involve exposures to chemicals and pyrolysis products (Austin et al., 2001a; Jankovic et al., 1991).

The primary route of exposure to chemical and biological hazards in firefighters is through inhalation; however, skin (including intradermal or even intravenous through puncture wounds) and oral exposures also occur. In addition to chemical hazards, firefighters are exposed to extreme physical hazards as reviewed below, as well as their possibly associated health effects.

2.3.1. Chemical Hazards

The major source of firefighters' chemical exposures comes from combustion (pyrolysis) products (Table 2.2). Characterization of these exposures, however, has proven difficult due to the lack of sampling and analytic methods as well as monitoring equipment compatible with the fire environment and due to concerns for firefighter safety during sample collection. A summary of available exposure measurements for combustion products is described below (Guidotti et al., 1992):

Particulates and Smoke

"Smoke" is the most obvious product of combustion. While it can be viewed simplistically as partially combusted carbonaceous materials, in reality, smoke consists of a bewildering array of organic and inorganic compounds unique to the combusted material, decomposed from the original material, and/or formed from the combustion process. Furthermore, the composition of combustion products can vary by the fire temperature (Jankovic et al., 1991).

The major component of smoke is both very fine and fine particulate, both of which are inhalable and have been linked in the air pollution literature to pulmonary and cardiovascular morbidity and mortality (Crapo, 1981). In addition to carbon particles, silica, fluoride, aluminum, lead, acids, bases, and phenols have been identified in the particulate phase of smoke (Large et al., 1990).

A number of studies have directly measured concentrations of particulates in fires. In a Buffalo study (Brandt-Rauf et al., 1988), particulate samples were collected at five fires in which the smoke intensity was described as "low" or "moderate." Concentrations of particulates in fires ranged from 10.1–344.4 mg/m^3. In another study of 22 mostly residential fires, total particulate concentrations ranged from nondetectable to 560 mg/m^3 during the knockdown phase to nondetectable to 45 mg/m^3 during the overhaul phase (Jankovic et al., 1991).

The exhaust of diesel engines typically used in fire apparatus is another source of particulate smoke exposure for firefighters. In one study, real-time continuous measurements showed total particulate concentrations frequently peaking above 1 mg/m^3 during departure of fire apparatus (Froines et al., 1987). Also, engines are typically kept running during the fire; although these trucks are typically outside, which does decrease exposure levels, firefighters interact continuously around the running trucks during the fire.

Carbon Dioxide

Carbon dioxide (CO_2) is naturally present in the atmosphere at levels of approximately 0.035%. Short-term exposure to CO_2 at levels below 2% (20,000 parts per million, or ppm) has not been reported to cause harmful effects. Higher concentrations can affect respiratory function and cause excitation followed by depression of the central nervous system. High concentrations of CO_2 can displace oxygen in the air, resulting in lower oxygen concentrations for breathing. Thus, the effects of oxygen deficiency may be added to the effects of CO_2 toxicity (http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/carbon_dioxide/health_cd.html) (Williams et al., 2000).

CO_2 is a product of combustion processes and is present in all fire environments. Concentrations range from normal background (350-400 ppm) to an excess of 100,000 ppm in "test fires" used in firefighter training (Burgess, 1979). Probably due to its relatively low toxicity, CO_2 exposures of firefighters have been measured in only a few studies. In more recent NIOSH studies, carbon dioxide concentrations ranged from 350–5,410 ppm in 19 samples during the knockdown phase. During overhaul, concentrations ranged from 130–1,420 ppm. CO_2 concentrations measured inside the SCBA mask ranged from 460–21,300 ppm levels, reflecting not only the active fire environment, but also the metabolic contribution of the firefighter's strenuous activity (Lees, 1995).

Carbon Monoxide

Carbon monoxide (CO) is present in virtually all fire environments as a product of incomplete combustion. CO is highly toxic, both acutely and chronically, and has long been recognized as a critical exposure of firefighters. Mild poisoning can cause such symptoms as nausea, dizziness, or headaches, while severe poisoning can result in brain or heart damage or even death (Burgess, 1979; Williams et al., 2000).

Many measurements of CO have been made during fires while firefighters are working. Measurements made under more severe than usual conditions showed CO concentrations exceeding 500 ppm approximately 29% of the time, with a measurement of 27,000 ppm as the highest concentration recorded (Burgess, 1979; Barnard and Weber, 1979). In a NIOSH study (Jankovic et al., 1991), CO concentrations ranged from the background level to 1,900 ppm in 33 samples during the knockdown phase; approximately 10% of the samples were above 1,500 ppm. During the overhaul phase, concentrations were considerably lower, ranging from the background level to 82 ppm in 7 samples. It should be pointed out that CO concentrations during forest and wildfire suppression were significantly lower due to lack of interior confinement, averaging only 14.4 ppm (Materna et al., 1992; Williams et al., 2000).

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is formed through the degradation of nitrogen-containing materials in fabrics and cellulose nitrate or through the fixation of atmospheric nitrogen. Short-term exposure at concentrations greater than 3 ppm can measurably decrease lung function. Concentrations as low as 0.1 ppm can cause lung irritation and measurable decreases in lung function in asthmatics. Long-term lower-level NO_2 exposures can destroy lung tissue, leading to emphysema (http://www.dnr.state.wi.us/org/aw/air/HEALTH/oxides.htm) (Williams et al., 2000; Rom, 1998). Measured concentrations of NO_2 at fires have ranged from 0–9.5 ppm in 240 samples; the highest exposure measured over a 5-minute period was 8.3 ppm (Burgess, 1979).

Hydrogen Chloride

Hydrogen chloride (HCl) is formed from the decomposition of chlorine-containing compounds and may be present as a gas or as an aerosol. Few reports are available on the effects of chronic HCl exposure on humans. Bleeding of the nose and gums and ulceration of the mucous membranes were observed after repeated occupational exposure to HCl mist at high but unquantified concentrations (Stokinger, 1981; Rom, 1998; Williams et al., 2000).

The typical source of chlorine is plastics, including both polyvinyl chloride (PVC) and the chlorinated acrylics that are extensively used in modern buildings and their interiors (e.g., wall and floor coverings, see Table 2.2). However, HCI is detected relatively infrequently in studies of firefighter exposure. In 90% of the fires examined, HCI concentrations were less than 50 ppm (Burgess, 1979; Treitman et al., 1980).

Hydrogen Cyanide

Hydrogen cyanide (HCN) is a particularly toxic gas. Occupational epidemiological studies of hydrogen cyanide exposure are complicated by the mixed chemical environments created by synthetic and metallurgic processes. Nevertheless, several reports indicate that chronic low exposure to HCN can cause neurological, respiratory, cardiovascular, and thyroid effects (Blanc et al., 1985; Chandra et al., 1980; El Ghawabi et al., 1975). Although these studies have limitations, particularly because of incomplete exposure data, they also indicate that long-term exposure to inhaled cyanide may produce central nervous system (CNS) and thyroid effects (Rom, 1998).

HCN is derived primarily from the combustion of nitrogen-containing polymers, such as the nitriles, polyamides, nylons, and polyurethane; it also can be formed during the combustion of paper, silk, and wool. HCN was detected in 10 of 26 fires; measured concentrations ranged from 0-75 ppm (Lees, 1995). In measurements made in 22 fires, HCN was detected during the knockdown phase in 12 fires and during the overhaul phase in 3 fires, with concentrations ranging from 0-23 ppm and 0-0.4 ppm, respectively (Jankovic et al., 1991).

Sulfur Dioxide/Sulfuric Acid

Sulfur dioxide (SO_2) is formed during the combustion of sulfur-containing materials. Low levels of SO_2 can cause lung irritation and measurable decreases in lung function in asthmatics. Upon contact with water applied as part of fire suppression, a significant amount may be converted into sulfuric acid. Elevated sulfate levels (1.6 ppb or 6.6 mg/m^3) have been significantly associated with pulmonary disease (Bates and Sizto, 1989; Williams et al., 2000).

In the Buffalo study, SO_2 was detected in 12 out of 26 samples from 14 fires and ranged in concentration from 0-41.7 ppm. Sulfuric acid was detected in 3 out of 22 fires in concentrations ranging from 0-8.5 mg/m^3 during knockdown and 0-0.9 mg/m^3 during overhaul (Jankovic et al., 1991). By contrast, SO_2 exposure while fighting forest fires was significantly lower, ranging from 0.2-2.9 ppm with an average of 1.5 ppm (Reh et al., 1994).

Acrolein

Acrolein is a highly irritant gas that at low concentrations can cause death in a relatively short time; the probable oral lethal dose ranges between 5 to 50 mg/kg. The acute and chronic effects of acrolein in humans consist mainly of upper respiratory tract irritation and congestion and eye irritation (http://www.epa.gov/ttn/uatw/hlthef/acrolein.html) (Williams et al., 2000).

Acrolein can be formed in the combustion of wood, cotton, paper, and plastic (including styrene and polyolefins), as well as oils and fats containing glycerol.

Depending on the material that is burned, acrolein concentrations vary by a factor of over 35 or more (Terrill et al., 1978). The acrolein concentrations measured during fires have been relatively stable. Most recent studies have shown that during knockdown, measured concentrations ranged from 0-3.2 ppm; during overhaul, concentrations ranged from 0-0.2 ppm (Jankovic et al., 1991). By contrast, studies of forest and wildfire exposures have yielded lower concentrations of acrolein, ranging from 0-0.01 ppm and 0-0.23 ppm, respectively (Materna et al., 1992; Reh et al., 1994).

Formaldehyde and Acetaldehyde

Formaldehyde and acetaldehyde are formed in a manner similar to the more toxic acrolein. They cause upper airway irritation and increased nasal airway resistance at concentrations ranging from 0.1 to 25 ppm and lower airway and chronic pulmonary obstruction at 5 to 30 ppm (NRC, 1981). These substances have been measured only in the more recent studies, as the result of improvements in sample collection technology. Formaldehyde was detected in 6 of the 24 samples in the Buffalo study, with concentrations ranging from 0.1-0.8 ppm (Jankovic et al., 1991). Data on aldehyde exposures in forest and wild fires are limited (Jankovic et al., 1991).

Benzene

Benzene frequently has been measured as a sampling surrogate for the staggering number of organic chemicals because of its basic nature, the relative ease of sampling and analysis, and its combined acute and long-term toxic effects. At extremely high levels (>2000 mg/m^3), benzene is capable of causing dizziness, headaches, and a variety of other symptoms. At levels above 3 mg/m^3, benzene has been linked to blood disorders and leukemia in chronically exposed factory workers. These workers were exposed by breathing benzene in the air and by absorbing it through their skin. Based on this evidence, benzene has been designated a "known human carcinogen" (Wallace, 1996; International Agency for Research on Cancer, 1987; Rom, 1998; Williams et al., 2000). Benzene is detected in nearly all fires. Measured concentrations have ranged from 0-230 ppm, with an average of 56 ppm (Brandt-Rauf et al., 1988; Caux et al., 2002).

Other Volatile Organic Chemicals

There are many other organic products of combustion (Austin et al., 2001b), but actual firefighter exposure measurements are rare and relatively recent. Many of these substances are known or suspected carcinogens. These chemicals include ethylbenzene, dichlorofluoromethane, methylene chloride, trichloroethylene, chloroform, perchloroethylene, toluene, and trichlorophenol. Exposure to these substances has been associated with increased respiratory disease and possibly with cancer (US Department of Health and Human Services, 1993).

Other Chemicals

Firefighters involved in fires may also encounter exposures with herbicides and pesticides (McMahon and Bush, 1992; Selala et al., 1993), diisocyanates (Davies, 1984), and the polychlorobenzene (PCBs) and related dibenzodioxins and dibenzofurans (Schecter, 1987; Hall et al., 1994). Most of these exposures occur as a result of particular industrial fires and are rare. However, these exposures may have long-lasting health effects such as increased cancer risk.

<u>2.3.2. Thermal, Noise and Physical Hazards</u>

Heat stress is compounded in firefighting by the combination of the insulating properties of the protective clothing and the extensive physical exertion required, resulting in significant endogenous heat production (Axford et al., 1976). Hot air from the fire alone is not usually a great hazard to the firefighter. However, inhaled steam or hot wet air can cause serious burns to the lower airway simply because of the high latent heat capacity, although steam inhalation is not common (Prien and Traber, 1988). Radiant heat is typical of a fire situation, and may be associated with skin changes, particularly erythema and telangiectasias, in the absence of obvious burns (Stevenson, 1985).

Several studies have documented that the noise exposure occurring in the cabin of the fire engine and the fire truck exceed the safe levels recommended by the Occupational Safety and Health Administration (OSHA) (Reischl et al., 1979). It has been reported that mechanical equipment generated sound levels that exceeded 115 dB for a period of 30 minutes (Davis, 1987). Noise-induced hearing loss in firefighters has been reported in several studies (Tubbs and Flesch, 1985; Reischl et al., 1981; Pepe et al., 1985).

Firefighters are also at grave risk from physical hazards such as being hit by falling heavy and sharp objects. These physical hazards are particularly dangerous because they occur in combination with the other fire dangers of heat, noise, and chemical exposures as well as extreme physical exertion and the necessity for rapid response to an emergency situation (Guidotti et al., 1992).

2.3.3. Biological Agents

Over the past 30 years, firefighters' jobs have changed radically, becoming less fire response and more emergency response. Fire service responsibilities are no longer limited to the traditional roles of extinguishment, search, and rescue. Increasingly, firefighters are cross-trained in emergency medical response roles. A recent national survey of U.S. and Canadian paid fire departments found that 90% of all firefighters provide some level of medical care in the community (Brunacini, 1993). On average, 77% of the fire departments in U.S. and Canadian cities with populations of 1 million or more provide first-responder services, 80% provide basic life support, and 50% provide advanced life support (Brunacini, 1993).

The increased emergency medical responsibilities place firefighters at risk for many of the communicable diseases that are well-known occupational hazardous exposures for health-care workers based in medical facilities, such as tuberculosis, hepatitis B, hepatitis C, hepatitis D, and human immunodeficiency virus (HIV) (Carrillo et al., 1996).

2.3.4. Psychological Hazards

Firefighting ranks among the most stressful occupations in the American workplace (Gist and Woodall, 1995). A firefighter regularly steps into a situation that others flee, thus accepting a level of personal risk that would be unacceptable in most other occupations. This was clearly demonstrated by the New York City firefighters' heroic efforts exhibited in the September 11, 2001 terrorist attack at the World Trade Center in which 343 firefighters lost their lives in the line of duty. According to the Associated Press, "Nearly a year after rushing to the World Trade Center, nearly 600 firefighters and paramedics remain on leave or limited duty because of respiratory problems or stress," and "A total of 250 were on leave with stress-related problems" (http://www.sptimes.com/2002/09/10/911/Cough__stress_hinder_.shtml). Although this risk is controlled to the extent possible with fire equipment and personal protection, the reality of firefighting is that much can go wrong in any fire, and the course of a serious fire is often unpredictable (Markowitz et al., 1987). Physiological and biochemical indicators of stress have been assessed among firefighters (Dutton et al., 1978).

2.4. Health Effects

The health impact of firefighting is influenced by several factors. These factors include the toxicity of fire exposures, the effectiveness and usage of personal protection equipment, and the fitness and personal health practices of firefighters. Generally speaking, firefighters who entered service before the 1960s were exposed to smoke of less acute toxicity (e.g., less exposure to the by-products of plastic combustion), but they lacked personal protection equipment of acceptable effectiveness. Those entering within the last 3 decades have primarily been exposed to smoke of greater toxicity, but have had more effective respiratory protection available. Firefighters who joined the force in the last decade may have the benefit of both fire-retardant materials produced under more stringent safety codes as well as respiratory protection meeting contemporary standards of effectiveness (Guidotti et al., 1992).

2.4.1. Acute Health Effects

Injuries

Injuries reported during firefighting include burns, falls, and injury from falling objects. Injuries associated with emergency medical response include musculoskeletal injuries and needlesticks. According to Cimino and colleagues (1995), more than 20,000 firefighters were burned in the line of duty between 1990 and 1993. Fire and smoke are responsible for a large portion of death and injury and are the largest threat to life at the fire ground. In the September 11, 2001 Twin Towers tragedy, 343 firefighters died, mostly from the structure collapse caused by the fire (http://www.ncfff.org/news_detail.asp?NewsID=35). Burns and smoke inhalation accounted for 22% of the fire ground injuries incurred by firefighters in 1990–1993 in the U.S. (Karter et al., 1994; Washburn et al., 1995). According to Heineman et al. (1989), 32% of burn injuries were first-degree burns, 65% were second-degree burns, and the remaining 3% were third-degree burns.

Fatal and nonfatal falls are another important source of injury for firefighters. Falls tend to be associated with SCBA use and with assignment to truck companies with climbing equipment. Age and experience do not seem to be associated with risk of injuries in service (Heineman et al., 1989).

Compared to other occupations, significantly increased musculoskeletal injuries in firefighters have been documented in both firefighting and medical emergency response (Reichelt and Conrad, 1995). Musculoskeletal injuries account for almost half of all line-of-duty injuries among the 1 million firefighters in this country (Karter et al., 1994) and result in significant lost work time, costly medical claims, permanent disability, and premature retirement. These injuries are primarily sprains and strains, as well as muscular pain that most frequently affects the back (Matticks et al., 1992).

Respiratory Disorders

Exposure to smoke and fumes from fires can lead to acute respiratory disorders. Smoke inhalation may account for up to 75% of fire-related deaths (Shusterman et al., 1993) and is often combined with burns and other trauma. Acute pulmonary effects can result from unremarkable fire exposures (Axford et al., 1976), as well as fires involving certain chemicals and their pyrolysis products such as burning polyvinyl chloride, silicone plastic, butyl rubber insulation, and isocyanates (Bergstrom et al., 1988; Sheppard et al., 1986).

There are 3 primary mechanisms of injury in smoke inhalation: asphyxiation, thermal damage, and pulmonary irritation. Asphyxia can result from primary lack of oxygen in fire, carbon monoxide poisoning, cyanide poisoning, or more rarely, the production of methemoglobinemia from exposure to aerosols containing nitrogen. Thermal inhalation injury is caused by hot gases produced by fire and primarily affects the upper airway as a burn. The pathophysiology of pulmonary irritant injury includes direct caustic injury, which is usually from exposure to the volatile products of fire with resulting inflammatory reactions to inhaled gasses and particulate matter (Burgess et al., 2001; Harrison et al., 1995).

Clinical manifestations depend on the specific mechanism of injury. Coma and cardiovascular compromise can be the result of significant anoxia. Upper airway edema from heat injury can lead to airway compromise. Inhalation of irritant gases and particulate matter can cause a wide range of pathologic processes and clinical sequelae that account for many of the acute and delayed effects of smoke inhalation (Bergstrom et al., 1988).

2.4.2. Chronic Noncancer Health Effects

The chronic effects of greatest concern in studies of firefighters have been lung cancer, heart disease, and chronic obstructive pulmonary diseases (COPD). Recently, other forms of cancer, particularly genitourinary and colon/rectal, have also been suggested to be associated with firefighting.

Cardiovascular Disease

Heart disease has long been recognized as a significant occupational health risk for firefighters. Currently, 36 states have some type of cardiac presumption disability law for firefighters that assumes that cardiovascular disease in firefighters is occupational in origin (IAFF, 1994).

The pathophysiology of cardiovascular disease development is probably multi-factorial. Firefighters may be directly exposed to carbon monoxide inhalation and elevated epinephrine levels from stress that have direct cardiac toxicity; firefighters also experience high occupational psychological and posttraumatic stress due to their variable work schedules and hazardous occupational exposures (Dutton et al., 1978; Guidotti et al., 1992). Other important risks may include tobacco use and less-than-optimal nutritional intake, as well as the strenuous physical demands of firefighting.

Mortality studies that compare the cardiovascular disease mortality experience of firefighters with the general population have documented an increased risk of mortality among firefighters. An early study of Toronto city firefighters found a significantly increased risk of cardiovascular-renal disease mortality (Mastromatteo, 1959). This increase was especially pronounced among firefighters aged 50-59. In another report of 101 firefighters who had died on the job, 45 (45%) died from heart attacks (IAFF, 1976). However, other more recent studies have found a significant decreases in heart disease mortality among firefighters in Boston and in Sweden (Musk et al., 1978; Tornling et al., 1994).

Chronic Pulmonary Disease

Most epidemiological studies of firefighters' mortality from chronic obstructive airways disease do not show an excess mortality risk compared to the general population. In part this may be due to the healthy worker effect (HWE) (i.e., those persons with chronic pulmonary disease retire early from the strenuous physical demands of firefighting). However, when compared to other occupational groups with comparable occupational fitness requirements such as police officers, firefighters have been shown to be at an increased risk of death due to nonmalignant respiratory disease in several studies (Scannell and Balmes, 1995). There is also evidence that firefighters are at risk for chronic airway obstruction, possibly due to their chronic occupational respiratory exposures (Sidor and Peters, 1974).

Of note, the prevalence of smoking among actively working firefighters is lower than that of other blue-collar occupations (Nelson et al., 1994).

2.4.3. Cancer

Firefighters are routinely exposed to a variety of carcinogenic substances during actual firefighting and its aftermath (i.e., overhauling) (Guidotti et al., 1992). Carcinogens such as benzene and polycyclic aromatic hydrocarbons (PAHs) (eg, benzo(a)pyrene) have been frequently detected in fire smoke (Caux et al., 2002). Other carcinogens including polychlorinated dibenzofurans and dibenzo-p-dioxins, formaldehyde, metals (such as chromium and cadmium), aromatic amines, and various chlorinated hydrocarbons have also been found at fire scenes (Demers et al., 1994).

Because of their occupational exposure to known or potential carcinogens, it has been assumed that firefighters would show an excess risk of cancer. Epidemiological studies have clearly demonstrated an increased risk for several cancers that can be plausibly linked with the carcinogenic exposures encountered by firefighters in the course of their work. Although increased overall cancer risk has not been observed in most firefighter studies (Howe and Burch, 1990), substantial and consistent epidemiological evidence suggests excess mortality for leukemia, non-Hodgkin's lymphoma, multiple myeloma, and cancer of the brain and bladder (Golden et al., 1995). Weaker but still plausible evidence links firefighting to increased mortality risks for melanoma and cancer of the rectum, colon, stomach, prostate, and lung (Golden et al., 1995). Table 2.3 summarizes most of the previous firefighter studies on cancers of the lung, colon, rectum, bladder, kidney, and brain.

Lung Cancer

As discussed above, firefighters may be routinely exposed occupationally to many known or suspected lung cancer carcinogens such as asbestos, arsenic, PAHs, vinyl chloride, and formaldehyde. Inhalation exposure can occur during active fire suppression, as well as during the overhaul phase, when protective-breathing equipment is often removed (Golden et al., 1995). Therefore, lung cancer has been specified a priori in the majority of epidemiological studies of cancer in firefighters as an outcome that would be plausibly related to firefighting.

Numerous studies have reported a slightly increased lung cancer mortality risk in firefighters, although not necessarily at a level achieving statistical significance (Hansen, 1990; Demers et al., 1992; Baris et al., 2001). The reason may be due in part to the small number of lung cancer deaths identified in these studies. Furthermore, if an occupational effect exists for lung cancer among firefighters, it could easily be obscured by confounding factors such as tobacco use and duration and intensity of individual exposure (Guidotti, 1995). As noted above, the prevalence of smoking among actively working firefighters is lower than that of other blue-collar occupations (Nelson et al., 1994). Among the few studies that have been able to examine individual exposures, a significantly elevated mortality risk for lung cancer has been reported among firefighters with the highest exposures (Guidotti, 1993; Heyer et al., 1990; Hansen, 1990).

Bladder Cancer

An increased mortality risk for bladder cancer among firefighters has been reported in studies of Buffalo (SMR = 2.86; 95% CI = 1.30-5.40) and Massachusetts firefighters (standardized mortality odds ratio (SMOR) = 2.11; 95% CI = 1.07-4.14) (Vena and Fiedler, 1987; Sama et al., 1990). Potential identified causes included inhalation exposure to PAHs, benzene, coal tars and pitches, soot, and oils (Silverman et al., 1986). Excess bladder cancer had been observed previously among other workers exposed to combustion products, including chimney sweeps (Gustavsson et al., 1988) and aluminum smelter workers (Armstrong et al., 1986).

Nevertheless, because all of the above-mentioned studies were based on mortality data without controlling for smoking, it is possible that the observed bladder cancer excess among firefighters was related to cigarette smoking. However, as noted above, the prevalence of smoking among actively working firefighters is lower than that of other blue-collar occupations (Nelson et al., 1994). Furthermore, since lung cancer, which is much more strongly correlated with smoking, is not significantly elevated in most firefighter studies, it is unlikely that the excess bladder cancer in this occupational group is completely due to smoking.

Kidney and Ureter Cancer

Occupational exposures including PAHs, lead phosphate, dimethyl nitrosamine, coke-oven emissions, and gasoline (all encountered in firefighting) have been implicated as risk factors for renal cell carcinoma (International Agency for Research on Cancer, 1987). A significant excess mortality for kidney and ureter cancer among firefighters has been documented (Burnett et al., 1994). Guidotti (1993) reported a SMR of 4.14 (95% CI = 1.66-8.53) for kidney and ureter cancer among Alberta (Canada) firefighters. However, results from studies of Washington state firefighters have failed to confirm these associations (Demers et al., 1992; Demers et al., 1994).

Prostate and Testicular Cancer

Evidence of excess prostate and testicular cancer among firefighters is equivocal. A proportionate mortality (PMR) study by Grimes et al. (1991) from Honolulu (Hawaii) found a statistically significant increase for prostate cancer in both Caucasian (PMR = 3.70; 95% CI = 1.71-8.02) and Hawaiian (PMR = 3.35; 95% CI = 1.07-10.45) firefighters. However, no associations (Giles et al., 1993) and even reverse associations (Beaumont et al., 1991) have been documented in other firefighting groups.

It should be noted that prostate cancer has a relatively low fatality rate, and therefore these mortality studies may have underestimated prostate cancer risk in firefighters. In a cancer incidence study, Demers et al. (1994) reported a 40% increased risk of prostate cancer in firefighters as compared to the general population (SIR = 1.4; 95% CI = 1.1-1.7).

Few epidemiological studies have investigated testicular cancer in firefighters. Excess risk was observed in two studies, but neither study achieved statistical significance due, in part, to small sample sizes (Giles et al., 1993; Aronson et al., 1994). A recent German population-based case-control study showed an increased risk for testicular cancer in firefighters, although again due to the small number (only 4 cases in the study), the finding did not reach the significance level (OR = 4.3; 95% CI = 0.7-30.5) (Stang et al., 2003). However, given firefighters' exposures to solvents and paints that have been implicated in the etiology of this cancer (Fleming, 1994), testicular cancer risk should be assessed in future studies of firefighters.

Brain Cancer

One of the most consistent associations between firefighting and neoplasms is brain cancer. Chemical exposures that are suspected causes of brain tumors include: benzene, PAHs, vinyl chloride, N-nitroso compounds, triazenes, and hydrazines (International Agency for Research on Cancer, 1987). Excess risk for brain cancer in firefighters is most notable within 15-30 years of exposure – i.e., after a relatively short latency (Aronson et al., 1994; Demers et al., 1992). Howe and Burch (Howe et al., 1990) analyzed all cancer mortality studies of firefighters available as of 1989, and suggested that firefighters might have an excess risk of mortality from brain cancer (pooled SMR = 1.43; 95% CI = 0.93-2.12). Furthermore, a recent large study among firefighters indicated a clear excess of cancer of the brain and other nervous system tumors, with an SMR of 2.09 (95% CI = 1.31-3.17) (Demers et al., 1992). Ma et al. (1998) also reported an excess mortality risk for brain tumors, particularly among black firefighters.

Lymphohemotopoietic Cancers

Excess mortality from cancers of the hematopoietic and lymphatic system (including leukemia, non-Hodgkin's lymphoma, and multiple myleoma) has also been previously reported among firefighters (Sama et al., 1990; Figgs et al., 1995; Ma et al., 1998). There is mounting evidence that leukemia and lymphoma are associated with environmental and occupational exposure to benzene and 1,3-butadiene (International Agency for Research on Cancer, 1987). The use of benzene as a solvent, a component of gasoline, and a combustion product that forms during the burning of plastics and synthetics and the use of 1,3-butadiene, a monomer found in tires and synthetic rubber products, guarantee that firefighters will be exposed occupationally to the gases released by these materials as they burn (Golden et al., 1995).

Digestive System Cancers

Firefighters are also exposed to a wide variety of suspected chemical carcinogens including asbestos, dyes, solvents, and metallic compounds that have been associated with an increased risk of cancer of the digestive system (Frumpkin, 1994; International Agency for Research on Cancer, 1987). Excess rectal cancer has been found in many firefighter studies (Aronson et al., 1994; Bates, 1987; Burnett et al., 1994; Demers et al., 1994; Giles et al., 1993; Guidotti et al., 1992; Vena et al., 1987). A similar pattern is also evident for colon, colorectal, or other "intestinal" cancers (Demers et al., 1994; Demers et al., 1992; Eliopulos et al., 1984; Giles et al., 1993; Guidotti et al., 1992; Vena et al., 1987), although the magnitude of the risk tends to be slightly lower. A recent retrospective cohort mortality study among 7,789 Philadelphia firefighters employed between 1925 and 1986 found a significant excess mortality risk for colon cancer (Baris et al., 2001). Excess risk among firefighters for other cancer sites of the digestive system (such as the liver, the pancreas, the stomach, and the esophagus) have also been documented (Beaumont et al., 1991; Sama et al., 1990; Demers et al., 1994; Demers et al., 1992; Vena et al., 1987), although the results are based on a few cancer deaths and are not consistent across studies.

Skin Cancer

Elevated cancer mortality for skin cancer has been consistently documented in a number of firefighter studies (Sama et al., 1990; Feuer and Rosenman, 1986; Burnett et al., 1994). This finding is not surprising because firefighters are exposed to soot and tars, arsenic, PAHs, and PCBs as well as uv light – all are risk factors that are associated with skin cancer, particularly squamous cell carcinoma (International Agency for Research on Cancer, 1987).

In a meta-analysis, Howe and Burch (1990) combined the results of the firefighters' cancer studies as of 1989 and showed that the risk for melanoma was significantly elevated (pooled SMR = 1.73; 95% CI = 1.03-2.74). However, they concluded that several criteria used to define a causal association were not fulfilled. For example, potential confounders such as sunlight exposure were not ruled out.

2.5. Limitations and Discussion

Although there is a large body of literature on firefighters' occupational exposures and their health effects, particularly on firefighters' mortality experience, some limitations of the epidemiological data should be discussed.

A number of unusual epidemiological characteristics influence the interpretation of studies of firefighters and their occupational mortality and morbidity. Firefighters do not show a strong HWE in most cohort mortality studies in which excess site-specific cancer or cardiovascular disease mortality has been reported. The absence of this effect may suggest an excess mortality from some cause(s) that is partly concealed by the

HWE. According to Guidotti (1995), there are two HWEs that may exist in firefighter studies. One operates at the time of hire, when new workers are screened for firefighting duty. Because of the strenuous fitness requirements for duty, this effect is very strong and might be expected to have an effect of reducing mortality from cardiovascular disease in the early years after being hired. The second HWE occurs when workers who become unfit after employment because of chronic illness or disability are removed from the workplace, reassigned to other duties, or are lost to follow-up. This second HWE is also called the "healthy worker survivor effect." Despite these occurrences, the HWE tends to fall off with time since the beginning of employment in firefighting (Howe et al., 1990). Because the epidemiological studies generally cover long periods of follow-up, it is unlikely that any positive association will be masked by the HWE.

Almost all firefighters' studies utilized mortality as opposed to incidence data. To date, there is only one published cancer incidence study of firefighters. Results of this study showed that only prostate cancer (SIR = 1.4, 95% CI = 1.1-1.7) was increased (Demers et al., 1994). It is theoretically possible that an occupation can be associated with differential survival as opposed to the risk of developing cancer. The fact that causes of death have been identified from death certificates does raise the possibility of misclassification, but this should not bias estimates of relative risk unless the misclassification rate is different for firefighters compared with the general population. It therefore seems unlikely that this form of bias is present. Nevertheless, as pointed out above, mortality studies will underestimate occupational association with some chronic diseases, such as prostate cancer.

Most of the studies examined relatively small populations of firefighters and thus have low statistical power to analyze rare tumors. The results of many firefighters' studies could be affected by the lack of information on confounding factors, such as lifestyle (e.g., smoking, alcohol, and diet), socioeconomic status, or other occupational and environmental exposures related to disease outcomes.

The most important methodological concern in firefighters' studies is the lack of specific exposure data. If risk is restricted to a subset of the cohort (e.g., those who participate in "knockdown" activities), such an effect is inevitably diluted in cohort studies of firefighters as a whole. The extent to which this dilution might occur cannot be ascertained, but the magnitude of any positive causal association might be substantially reduced because of this problem. In addition, as described above, the wide range of exposure types, intermittent and variable exposures, and changing exposure scenario (e.g., the first arriving on the fire scene versus the late arriving; the use of personal protection) also make it difficult to characterize the association between cancer risk and firefighting. Despite the limitations cited above, the available exposure assessment and epidemiological studies present convincing and consistent evidence that the toxic exposures encountered in firefighting may increase risk for certain specific cancers as well as other acute and chronic health effects.

CHAPTER THREE: RESEARCH DESIGN AND METHODS

This chapter is divided into two parts. The first part describes the databases used, the data linkage, and the procedures and criteria used to create a master database for further statistical analyses. The second part of the chapter discusses the statistical methodology and other issues.

3.1. Databases

Several databases were used in the present study to create a "master study database" through linkages. These databases include: 1) Florida firefighter /volunteer data file; 2) Florida Cancer Data System; 3) Florida Vital Statistics (also called Florida Death Tapes; the two were used interchangeably in this dissertation); 4) Florida Motor Vehicles Database; and 5) Health Care Financing Administration (HCFA). Brief descriptions of these databases are given below.

3.1.1. Florida Firefighter/Volunteer Database

Beginning in 1972, certification has been required for all firefighters to work in the state of Florida. Certification entails physical fitness testing, training, and a written exam for competency in the demanding firefighting profession. Nevertheless, both professional and volunteer firefighters existed before 1972, including subsequent participants in the certification system.

A Microsoft Access data file provided to the investigators by the office of the Florida Fire Marshals included four tables: 1) firefighters, 2) certification, 3) fire department, 4) employment history. These data were entered by staff of the office of the Florida Fire Marshals from paper records; all available hardcopy data were entered. These data are described in the following tables (Tables 3.1-3.3). Of note, the database program was on a mainframe at the time, and no data validation method was used; hence, errors are to be expected.

The firefighters' database contained 79,733 records with the following information: name, social security number, date of birth, address, county code, fire department code, type, and employment date. Of note, employment date was available only for current professional firefighters (Table 3.1).

Certification information was available for the 39,455 professional firefighters with 3 fields: social security number, certification type, and certification date (Table 3.2). For the purposes of this study, certification date was considered the start date of firefighting exposure for the professional firefighters; as noted above, persons who were certified in 1972 could have been exposed to firefighting before that date. Because volunteer firefighters do not have certification data, it was not possible to determine the start date of their firefighting exposure.

Employment history records were available for professional firefighters no longer in service, with fields including social security number, employment date, department code, termination date, and termination type. A total of 23,580 records were available in this category (Table 3.3).

The 3 databases described above (i.e., firefighter/volunteer, certification, and employment history) were merged to create a "master firefighter" database (see section 3.1.7: Creation of Master Database for details). Information on employment or certification type was ultimately not used in the analysis, due to the substantial number of missing records as well as the difficulty in using this information as a proxy for determining level of firefighting exposures. For example, according to the reference provided by the Florida Fire College, 17 different types of certificates were used. In the certification database, however, only 2 valid certification types were found (i.e., minimum standards and forestry compliance), and 84% of the certified firefighters were with the minimum standards certification. In addition, "deceased" was used as one of the employment types in the firefighter/volunteer database. The Florida Fire College had advised us against using the employment or certification type as a proxy measure of exposure because of these errors or missing records.

3.1.2. Florida Cancer Data System (FCDS)

Under the Florida Department of Health (formerly known as the Florida Department of Health and Rehabilitative Services), the Florida Cancer Data System (FCDS) has collected all incident cancer cases diagnosed in Florida residents since 1981. It is one of the largest statewide, population-based cancer registry systems in the United States, collecting data on over 80,000 new cancer patients per year. The FCDS covers 100% of Florida's population, which comprises nearly 7% of the U.S. population. Two hundred forty seven hospitals throughout the state report their cancer cases to FCDS. FCDS estimates that it has captured at least 95% of all incident cancer cases in the state of Florida since its inception. At this time, FCDS has collected information on more than 1.3 million incidence cancer cases (http://fcds.med.miami.edu/inc/info.shtml).

For FCDS purposes, "cancer" is defined as any malignant tumor that arises as a result of abnormal or uncontrolled division of cells and is categorized as invasive or noninvasive (in situ); basal and squamous cell carcinomas of the skin are not reported to FCDS (FCDS 1989). There is at most a 6-month reporting delay for FCDS. The data items collected for FCDS are now compatible with national standards set by the

Surveillance, Epidemiology, and End Results (SEER) reporting program (FCDS 1989). Individual researchers can apply to the FCDS for data linkage using personal identifiers such as social security number and name. Information on tumor-specific diagnosis and histology, as well as information extracted from the medical record at the time of diagnosis of the cancer case on age, sex, and race/ethnicity is available for those found in the FCDS files. Data linkage using an algorithmic match is available for a scheduled fee, after applying to Florida HRS; prior Human Subjects Committee approval and FCDS peer review are required.

3.1.3. Florida Vital Statistics Records

Records of the Florida Department of Health and Human Services Office of Vital Statistics have been computerized, with complete information from 1970 through 2000. With name and social security number, it is possible to link these records for confirmation of death using a deterministic match (i.e., the fields used in the linkage agree "exactly," e.g., social security number in the Florida Vital Statistics equals to the SSN in the firefighter database).

Information available for linked subjects includes: date of death, date of birth, gender, race, place of death, and specific cause of death.

3.1.4. Florida Motor Vehicles

The Florida Department of Highway Safety (Division of Licensure) maintains a computerized motor vehicles database with records on more than 12 million Florida residents by name, sex, home address, and date of birth; recently they have also added social security number. It is estimated that fewer than 500,000 eligible Florida residents (i.e., at least 15 years of age without certain health restrictions) are unlicensed. Licenses must be renewed every 6 years, and records are cleaned 15 months after failure to renew. Individual records are available to the general public, and computerized linkage with other data sets is possible for researchers. The Florida Highway Safety database was used to help confirm the vital status of the firefighters during the follow-up period.

Data linkage using a deterministic match is available for a fee, after application through the Department of Highway Safety. Information available for linked subjects includes: driver's license number, name, date of birth, sex, race, address, and date of death (if applicable).

3.1.5. Health Care Financing Administration (HCFA)

HCFA, a federal agency located in Maryland, is responsible for monitoring the federally funded Medicare system. For researchers, HCFA performs linkages with their files of all persons who are receiving or have received Medicare (65 years or older) or disability benefits (any age after 30 months of receiving social security disability benefits), including family members. The HCFA database, which includes both active (approximately 38 million) and inactive files, has more than 80 million records dating back to the 1960s. The majority of Americans over the age of 65 are in the HCFA system; exceptions include persons dying before age 65, persons who never apply for Medicare, persons younger than 65 who die within 30 months of applying for disability, certain federal employees, and undocumented persons.

Linkage with the HCFA database is available using a deterministic match. Information is available on gender, race, date of birth, last residence, and date of death, as applicable.

The HCFA database was used as the last resort to limit the number of "lost to follow-up." The National Death Index (NDI) and other useful national mortality linkages were not pursued in the present study because of budget constraints.

3.2. Data Linkages

The firefighter database was provided in Microsoft Access format. It was imported into SAS version 8 (SAS Institute, 1986) and used as a core database in all linkages to create a "master study database" for final analyses. Social security number was used as the unique identifier. Each subject in the master database was assigned a study ID number to avoid duplications due to multiple database linkages.

The Florida firefighter database was linked with several databases – Florida Motor Vehicles, the Florida Cancer Data System (FCDS), the Florida Vital Statistics, and the Healthcare Finance Administration (HCFA) – to obtain date of birth, cancer incidence, death, and other information (see Figure 3.1). Firefighters not found in one of these databases (and thus missing date of birth and vital status) were considered "lost to follow-up" and not included in the final analysis.

3.2.1. Creation of the Master Firefighter Database

The master firefighter database was initially created by merging 3 tables from the Microsoft Access file – namely, the firefighters/volunteers table, certification table, and employment history table as described above. A description of the merging process is given below.

Each observation in the firefighter/volunteer database (79,733) was assigned a unique ID number. The firefighter/volunteer database was merged with the employment file by social security number. The employment history file contained 23,580 records.

Because of on and off employments, a firefighter might appear more than once. For those with multiple employments, only the record for the first employment was kept. A total of 19,384 firefighters from the employment file were therefore merged to the firefighter/volunteer database. The certification data file contained 39,445 records among which 277 firefighters had more than one certification date. In these cases, the earlier certification date was used and the late one(s) deleted. Thus, 39,178 firefighters with certification information were used in the creation of the master firefighter database.

The merged master firefighter database initially contained the following variables: ID number, name, address, fire department county location, fire department code, social security number, date of birth, employment date, firefighter type, certification date (professional firefighters only), certification type (professional firefighters only), termination date (firefighters no longer in service), and termination type (only firefighters no longer in service). There were 5 termination types: deceased, disabled, involuntary, resigned, and retired. Information on termination type was not used in the analysis due to the substantial amount of missing information in this field.

Substantial date-of-birth data were missing and no information was available on gender and race/ethnicity in the master database. Data linkages were performed to supply additional information on date of birth and demographic variables, as well as vital status and cancer incidence.

3.2.2. Linkage with Florida Motor Vehicles

An ASCII file containing only social security number was developed for the Florida motor vehicles linkage. Data linkage was performed by the Florida Department of Motor Vehicles for the entire 79,733 firefighters/volunteers using social security number as the unique linkage key in a deterministic match (i.e., matching exactly by SSN). A total of 71,189 positive links were returned to the investigator, supplying information on driver's license number, first name, middle name(s), last name, suffix, race, sex, date of birth, address, and date of death for the deceased for those linked. Of note, the race data were provided by the applicant when filling out the motor vehicle application; death data were recorded but were considered to be incomplete.

Out of 71,189 positively linked, 69,753 had been uniquely linked between the firefighters database and Florida Motor Vehicles, the rest (1,436) had multiple "hits" (i.e., a firefighter might be linked to 2 or more individuals). In the latter case, the full names from the firefighter database were compared to the full names obtained from the Florida Motor Vehicle database. Only those with completed matched full names were considered "true matches." After manually comparing the full name obtained from the linkage with the full name in the firefighter database, 582 observations were kept. The reason for multiple matches was probably due to husband and wife or father and son sharing the same social security number, or incorrect social security numbers.

A total of 70,335 positive links were achieved using the Florida Motor Vehicles linkage, which provided information on date of birth and vital status for linked firefighters. If a firefighter was matched in the Motor Vehicles database and was not dead by other linkages, then the firefighter was considered to be alive in the last 6 years and "alive" for the purposes of this study.

3.2.3. Linkage with Florida Cancer Data System (FCDS)

An ASCII data file containing social security number, name, and date of birth was provided to FCDS for linkage. Data linkage of the entire firefighter database was performed by the FCDS. The linkage used social security number, name, and date of birth. Linkage provided date of birth, date of cancer incidence, gender, race, ethnic group, and type of cancer information, as well as other variables.

The FCDS uses AUTOMATCH software to perform algorithmic matching. The algorithm used for the linkage combined: a) exact social security number; b) exact social security number and the last name; c) 7+ digits of the social security number and the last name and/or 7+ digits of the social security number and the last and first initial. The investigators individually reviewed all matches.

The linkage identified 2,590 reports of cancer incidence among the firefighters/volunteers. Since cancer was reported more than once for some firefighters, the earliest diagnostic date for the first cancer was counted for the study analyses. For the purposes of this study, 1,848 incident cancer cases were thus identified.

Information obtained through FCDS linkage included date of birth, race, sex, cancer incidence, and vital status (death information in FCDS was obtained through linkage with the Vital Statistics annually).

3.2.4. Linkage with Florida Vital Statistics

The investigators performed data linkage with the entire firefighter database using the vital statistical data provided. Before beginning linkage, an ASCII file was created that excluded inappropriate social security numbers, persons who died at less than 18 years of age, or inadequate vital status information. The linkage was deterministic, using social security number only. This linkage provided date of birth, date of death, gender, race, cause of death, and other information.

After confirmation of name, duplicates were manually reviewed and eliminated. A total of 2,554 unique deaths were identified from the firefighter/volunteer cohort.

3.2.5. Linkage with Health Care Finance Administration (HCFA)

Data linkage was performed by the Health Care Finance Administration for the 7785 firefighters/volunteers not identified in the Florida Motor Vehicles, Florida Vital Statistics, or Florida Cancer Data System linkages. An ASCII data file containing social security number and gender was provided to HCFA for a deterministic linkage.

From HCFA, 1,517 matches were found. After manually checking with names in the master database, only 840 unique matches were confirmed. Full name, date of birth, date of death (if applicable), gender, race, and other information were obtained with the linkage.

Subjects found in the HCFA linkage were considered alive at the end of study unless there was a definite date of death.

3.2.6. The Master Study Database

Before beginning the final data linkage in the finalization of the master study database, gender, ethnic assignments/determination (Hispanic vs. non-Hispanic) were made for the whole cohort by the investigators as described below.

Gender Assignment

The gender assignment was applied to only 450 firefighters (0.6% of all firefighters included in the study). All first names were reviewed. Gender (male, female, unknown) was assigned by the investigator using Kolatch's Dictionary of First Names (Kolatch, 1990). Where there were "unisex" names (e.g., Leslie, Bobbie), male gender was arbitrarily assigned, since the vast majority of the firefighters have historically been male. In addition, all names accompanied by a Jr., Sr., or roman numeral (e.g., II, III) were first assigned male gender, while all names accompanied by "Mrs." were assigned female gender. Maiden names were included in the updated "first name" field, since none of the proposed database linkages listed maiden names as separate last names. Nicknames and abbreviations (e.g., Wm. = William) were replaced with full names where available. Initials (without a roman numeral, Jr., Sr., or Mrs.) were assigned "unknown" gender until further data linkage.

Ethnic Group and Race Assignment

Ethnic group (Hispanic, non-Hispanic) was based on the list of Hispanic surnames downloaded from the Surveillance, Epidemiology, and End Results (SEER) Web site and on the 1980 US Census List of Hispanic Last Names (obtained from the Bureau of the Census). Under reporting of Hispanic ethnicity is a problem when using only last names to determine status, especially with persons who are longer than second generation in the U.S. (Census, 1980; Rosenwaike et al., 1991).

Race (black, white, unknown) was gained through subsequent data linkage. Although not available in the original firefighter database, race was obtained for the majority of the firefighters through data linkages.

3.2.7. Data Linkage Hierarchy

The hierarchy of all databases used was based on 2 criteria. The first was to maximize the use of the data with regard to the proximity of the data source to the actual subject; the second was the thoroughness of the data linkage.

The firefighter database was considered to be the top layer in the hierarchy in this study because these were original data from hardcopy records created by the professional firefighters and volunteer firefighters themselves. This database was considered to be the most reliable source for the actual subjects.

The rest of the hierarchy was based on the thoroughness of the data linkage. The FCDS, although collected from medical records, has extensive quality control procedures to ensure the reliability of the data; in addition, an extensive algorithm, described above, was used to obtain the matches. Motor Vehicles hard-copy records were filled out by the subjects, but the data linkage was deterministic (exactly matched by only one variable, i.e., social security number). The Florida Death Tapes originated from death record extraction that was not filled out by the subject. HCFA records were derived from state and federal databases. Based on the above discussion, the following hierarchies were used in the crescendo of linkages both to obtain information (e.g., date of birth, date of death, gender) and to create the master study database for the purposes of subsequent statistical analyses.

1) Hierarchy and source for the date of birth:

- Firefighter database
- FCDS
- Motor Vehicles
- Florida Death Tapes
- HCFA

2) Hierarchy and source for the gender and ethnic group information:

- FCDS
- Motor Vehicles
- Florida Death Tapes

- HCFA
- Assignment by investigator (as described above)

3) Source for cancer incidence and death information:

- Cancer-incidence data were available only from the FCDS
- Cause-of-death data were available only from the Florida Death Tapes, although limited date-of-death information was available from Motor Vehicles, FCDS, and HCFA

3.2.8. Agreement between Database Linkages

Since all data linkages, with the exception of FCDS linkage, were carried out by a single unique identifying variable, i.e., social security number, certain degree of disagreements may exist between firefighter database and the database linked for variables such as date of birth, first and last name. Since no quality of assurance measures were taken when the data were entered in firefighter/volunteer file, it was likely that there were errors in some social security numbers. To assess the accuracy of the linkages, the agreements between firefighter database and the linked database for date of birth were examined (Table 3.4). The agreement for date of birth was the highest in Florida Motor Vehicles linkage (96.5%), followed by FCDS (94.2%), Florida Death Tapes (85.5`%), and HCFA linkage (82.8%). Between those disagreed, first and last name were further examined. Among the 1,616 disagreements in Motor Vehicles linkage, 1,338 (82.8%) had exactly the same name; only 278 (17.2%) had different names. The disagreement for both date of birth and name was less than one percent (0.6%).

Since most of the disagreements in date of birth were due to misplacement of month and day, we further evaluated if the disagreement was greater than a year for date of birth. The increases in agreements were obtained for all linkages using this criterion. Except for Death Tapes (89.8%), the agreements in the three other linkages all reached above 96%, indicating that the linked data were highly accurate.

3.2.9. Lost to follow-up

Any subject not found in any of the data linkages was defined as "lost to follow-up." There were 6,945 (8.7%) subjects lost to follow-up, among whom 2,272 were professional firefighters (5.8% of all professional firefighters) and 4,673 were volunteers (11.5% of all volunteers). The main reason for the lost-to-follow-up entries was that the study covered a span of 27 years (1972-1999) during which some firefighters/volunteers might have moved out of Florida. Errors in social security numbers provided in the firefighter data file could also prevent accurate tracking.

3.2.10. Description of Master Study Database

Professional firefighters/volunteers who met the following criteria were included in the master study database:

1) Valid social security number
2) Assigned a gender category
3) Designated vital status (including cancer incidence) during the study period (1/1/72 – 12/31/99) in Florida
4) Birth date assigned from one of the database categories by hierarchy as per above

By the multiple data linkages described above, the following data were available on all subjects in the master study database (except as noted):

- ID number
- Social security number

- Name
- Date of birth
- Gender
- Hispanic/non-Hispanic
- Race (limited information)
- Cancer incidence (where applicable)
- Date of death (where applicable)
- Initial certification date (for certified professional firefighters only)
- Initial certification type (for certified professional firefighters only)
- Employment date (limited information)
- Termination type (limited information)

A total of 72,788 firefighters/volunteers were included in the master study database.

3.3. Statistical Analysis

This study was a retrospective cohort study of cancer incidence and general mortality in Florida firefighters. The cohort consisted of volunteer and certified professional Florida men and women firefighters derived from the Florida Firefighters Union database as described above. The certification issue date was used as the entry point in the SMR study to the cohort for a professional firefighter (could be as early as January 1, 1972), but was available only for professional firefighters, not for the volunteer firefighters. December 31, 1999 was used as the closing date of the study. For the SIR study, because incidence data before 1981 were not available, January 1, 1981 was used as the entry point for the professional firefighters certified before 1981, and the actual certification date was used for those certified after.

For the retrospective cohort study of general mortality, exit from follow-up was defined as: the last year known to be alive in Florida (based on linkage with the Department of Motor Vehicles), the date of death (based on linkage with the Vital Statistics, FCDS, and HCFA), or the end of the study period, whichever came first. For the cancer incidence study, exit from follow-up was defined as the last year known to be alive in Florida, the date of incident cancer diagnosis (FCDS), the date of death (based on linkage with the Vital Statistics, FCDS, and HCFA), or the end of the study period, whichever came first.

The person-year calculations for the SMR and SIR study are illustrated in Figure 3.2.

3.3.1. Standardized Mortality/Incidence Ratios

Standardized incidence/mortality Ratios (SIRs, SMRs) were used to evaluate the overall and site-specific incident cancer risk and mortality risk among firefighters. The SIR and SMR are commonly used in occupational epidemiology when a suitable unexposed comparison group is not easily available, or is inadequate due to small population size. The advantage of using the general population as comparison is that these data are relatively easy to obtain and are stable due to large population size. The disadvantage is the potential bias from the HWE in the study cohort, as well as other potential biases arising from significant differences between the cohort and the general population in socioeconomic class, smoking, diet, and other potential confounding variables (Fox and Collier, 1976; Checkoway and Waldman, 1985). In this study, SIRs and SMRs were calculated using 1970 corresponding Florida general population rates as references. The indirect standardization method was used, and standardization was performed using 5-year age intervals (Breslow and Day, 1987). Confidence intervals were calculated for each SIR or SMR (Checkoway et al., 1989; Kelsey et al., 1996; Breslow et al., 1987). Because the methodology for SMR and SIR is the same, the following discussion will refer only to SMR, unless otherwise specifically noted. The principle behind standardization is to calculate hypothetical crude rates for each compared group using an identical artificial distribution for the factor to be standardized; the artificial distribution is known as the standard. SMR is usually indirectly standardized, often for gender, age, and calendar year. Breslow and Day (1987) defined age-adjusted SMR as a weighted average of the age-specific rate ratios where the weights are the expected number deaths for the i^{th} age group. The SMR is calculated as the ratio of the observed over expected, where a_i is the number of persons with a specific cause of death in the i^{th} stratum of age and time, and $E(a_i)$ is the expected number of people based on age and calendar-year-specific general population rates for that specific cause of death.

$$SMR = \frac{\sum a_i}{\sum E(a_i)} \times 100 = \frac{Observed}{Expected} \times 100$$

Obviously, the SIR would consist of a similar formula except that a_i is the number of persons with a specific cause of cancer incidence in the i^{th} stratum of age and time, and $E(a_i)$ is the expected number of people based on age and calendar-year-specific general population rates for that specific cause of cancer incidence. The 95% confidence intervals were calculated for the SMR in the following way, assuming a constant denominator (Rothman and Boice, 1979; Checkoway et al., 1989; Kelsey et al., 1996):

$$Lower\ limit = Obs\left[1 - \frac{1}{9(Obs)} - \left(\frac{Z}{3}\right)\left(\sqrt{\frac{1}{Obs}}\right)\right]^3 / Exp$$

$$Upper\ limit = (Obs+1)\left[1 - \frac{1}{9(Obs+1)} + \left(\frac{Z}{3}\right)\left(\sqrt{\frac{1}{Obs+1}}\right)\right]^3 / Exp$$

Where *Obs* is the observed number of deaths, and *Exp* is the expected number of deaths, Z is the standard normal deviate specifying the width of the confidence interval (i.e., Z = 1.96 for the 95% confidence interval). SMR/SIR analyses were applied only to certified professional firefighters for whom the certification dates were available. As described before, all certified professional firefighters included in this cohort analysis had a date of birth, initial certification date, and gender information; they were considered to be alive at the end of the study period, unless data linkages revealed a date and/or cause of death. For the SMR study, person-years started on the first calendar year and month of certification and ended with the date of death or at 12/31/1999, the end of the study period. For the SIR study, person-years started on the 010/1/1981 even for firefighters certified before that date, because the FCDS began collecting cancer incidence in that year – and ended with the date of cancer diagnosis, the date of death, or at 12/31/99, the end of the study period. The age and calendar-year groupings are in 5-year intervals, starting with age 20. Both SMR and SIR analyses were conducted only for professional firefighters since information on starting date for volunteer firefighters was not available. SMR/SIR were conducted separately for men and women professional firefighters. For women firefighters, the analyses were focused on documenting overall cancer incidence and mortality because of their small sample size. Hispanic versus non-Hispanic SMR/SIR were also performed to determine whether ethnicity plays a role in firefighters' cancer mortality and incidence risk.

3.3.2. Proportional Mortality Ratio

Proportional mortality ratio (PMR) studies are used in occupational settings when person-year information is not available. Frequently, the only information available in many occupational studies comes from the death certificates of a group of persons with the same occupation. The basic data available are the cause of death, the age at death, and the date of death. In a PMR, the expected number of deaths in a study group due to a specific cause is computed on the basis of the proportion (percentage) of that cause in the general population. The total number expected is divided into the total number observed (Monson, 1990).

$$PMR = \frac{\sum Observed}{\sum Expected} \times 100$$

The confidence interval is calculated using a Poisson distribution, when the observed observations are less than 50; otherwise, the 95% confidence interval is calculated (Ahlbom, 1993; Wiklund, 1983) as:

$$PMR \pm 1.96\sqrt{\frac{PMR}{Expected}}$$

PMR studies have the attractive feature of providing results relatively quickly and inexpensively. However, the validity of a PMR study depends on whether the deaths included are generally representative of all deaths that would be identified if follow-up of the full cohort had been conducted. Even when there is complete ascertainment of deaths, a shortcoming of the PMR approach is that when the PMRs for some disease are elevated, counterbalancing proportionate mortality deficits will occur for other causes.

This occurs because, by definition, the total number of observed deaths from all causes combined will equal the expected number. Nevertheless, the commonly held view appears to be that PMRs are good approximations to SMRs obtained from cohort studies when the cohort's all-causes combined SMR is equal to 1.0 (Checkoway et al., 1989). PMR studies were performed for both professional firefighters and volunteers. Unadjusted and age-adjusted PMRs were obtained for all firefighters, male versus female, and Hispanic versus non-Hispanic professional firefighters and volunteers.

The SAS System for Windows version 8.02 was used to perform all statistical analyses, including macros previously developed by Mr. Mark Rudolph, MS, and used by Dr. Fleming to calculate the SIRs, SMRs, and corresponding confidence intervals. Two-sided p-values were used, and the significance level was set at 0.05.

CHAPTER FOUR: RESULTS

This chapter describes the general characteristics of the Florida firefighters/volunteers cohort and discusses the results of the standardized incidence ratio analyses (SIR), the standardized mortality ratio analyses (SMR), and the proportional mortality ratio analyses (PMR) in a cohort of Florida firefighters, all using the general Florida population as the comparison group. Volunteer firefighters were also used as a comparison population in the PMR analyses. Volunteer firefighters shared many characteristics such as fitness, lifestyle, and tobacco use with the professional firefighters except for the level of occupational exposures. Using the volunteers as a comparison group provided us with an opportunity to control for the HWE and other confounding factors that are often implicated in occupational studies. Person-year data of exposure (i.e., certification date) were available only for professional firefighters; therefore, the SIR and SMR analyses were performed only for professional firefighters. Additional subpopulation analyses of women, Hispanics, and the male professional firefighters certified between 1972 and 1976 were also performed for the SMR and SIR studies.

4.1. Overall

Out of 79,733 firefighters in the master study database, 72,788 (91.3%) were found in data linkages described in Chapter Three and were included in the final analyses. Among them, 36,813 (50.6%) were professional firefighters, and 35,975 (49.4%) were volunteer firefighters.

Among professional firefighters, 2,017 (5.5%) were women and 2,592 (7.0%) were Hispanic, compared to 5,776 (16.1%) women and 1,792 (5.0%) Hispanics among volunteers. The distribution of gender and Hispanics among professional firefighters and volunteers for the entire cohort is shown in Table 4.1. The overwhelming majority was white, in both professional firefighters (32,944, 90.1%) and volunteers (32,211, 90.7%); blacks accounted for only 6.5% (2,377) of professional firefighters and 6.7% (2,388) of volunteers.

Certification date was available only for the professional firefighters, not for the volunteers. Among professional firefighters, the age at first certification ranged from 18 to 50 years (mean $\pm$ SD = 27.9 $\pm$ 7.0). The mean age at first certification for the Hispanic firefighters (26.6 $\pm$ 5.9) was significantly younger than for non-Hispanics (28.0 $\pm$ 7.0) ($p < 0.001$); Hispanic firefighters also had a shorter length of time of certification (10.3 $\pm$ 7.5 versus 14.3 $\pm$ 8.6) ($p < 0.001$) (Table 4.2). The average length of time since certification for the women professional firefighters (8.7 $\pm$ 5.7) was significantly shorter than for the men professional firefighters (14.3 $\pm$ 8.6) ($p < 0.001$) (Table 4.3).

Person-years by age group and gender for the professional firefighters are shown in Table 4.4. For the male cohort SMR study, a little less than two-thirds of the total person-years came from 18–39-year-old firefighters (62%), one-third came from 40–59-year-old firefighters (33%), and only 5% of total person-years were contributed by firefighters 60 years or older. The female cohort was even younger; 80% of the total person-years were from the 18–39-year-olds, 19% from the 40–59-year-olds, and about 1% from women firefighters 60 years or older. Most of the women firefighters entered the cohort after the late 1980s. The person-year distribution for SIR study was similar to that for SMR.

4.1.1. Cancer Incidence

1,848 incident cancer cases were identified in the cohort from 1981 (when the Florida Cancer Data System began collecting data) until 12/31/1999. Of these cancer cases, 1,022 (55.3%) were professional firefighters, and 826 (44.7%) were volunteers (Table 4.5). Among professional firefighters, there were 52 women (5.0%) and 37 Hispanics (3.6%); among volunteers, there were 146 women (17.7%) and 26 Hispanics (3.1%).

The overall mean age at cancer incidence was 47.7 ± 22.7 years. The mean age at cancer incidence was significantly older in professional firefighters (49.2 ± 19.6) than in volunteers (45.8 ± 26.0) ($p = 0.003$) and in male firefighters (48.6 ± 23.4) than in female firefighters (40.3 ± 14.6) ($p<0.001$). There was no significant difference for the age at cancer incidence between the Hispanic (49.6 ± 19.9) and non-Hispanic firefighters (47.6 ± 22.8) ($p = 0.52$).

The mean age at first certification was 35.3 ± 9.0 years among professional firefighters who had cancer; the average length of time certified was 17.5 ± 7.5 years; the mean age at death was 56.1 ± 11.8 years. Women professional firefighters who had cancer were significantly younger at first certification (31.6 ± 7.3 vs. 35.5 ± 9.1; $p = 0.004$) and at death (45.4 ± 9.9 vs. 56.2 ± 11; $p = 0.041$), and had a significantly shorter length of certification time than their male counterparts (9.0 ± 6.2 vs. 17.9 ± 7.3; $p = 0.001$) (Table 4.3). There were no significant differences between Hispanics and non-Hispanics in age at first certification (35.7 ± 10.0 vs. 35.2 ± 9.0), age at death (53.4 ± 15.8 vs. 56.2 ± 11.6), or length of certification (21.3 ± 8.2 vs. 22.3 ± 6.8).

The most prominent cancer in male firefighters was prostate (23.1%), followed by lung (13.7%), skin (8.4%), colon (7.1%), bladder (6.9%), and testicular (5.5%). The most prominent cancer in female firefighters was breast (27.8%), followed by skin (7.6%), thyroid (5.6%), and lung (4.6%). The proportions of site-specific cancer incidence in Hispanics were higher for thyroid (9.5%) and Hodgkin's disease (7.9%) than in non-Hispanics (thyroid: 2.0%; Hodgkin's 1.4%); but non-Hispanics had higher proportions of lung (12.9% vs. 6.4%) and skin (8.5% vs. 3.2%) cancer.

4.1.2. Overall and cause-specific Mortality

A total of 2,639 deaths were identified in the cohort from 1972 until 1999. More than half of these deaths occurred in professional firefighters (1,416 [52.6%]). In the entire cohort there were 136 (5.1%) female deaths and 89 (3.3%) Hispanic deaths (Table 4.5).

The mean age at death was 52.8 ± 15.9 years overall, 52.5 ± 12.7 for professional firefighters and 53.2 ± 17.2 for volunteers ($p = 0.31$). Women died at a younger age versus men firefighters (47.7 ± 15.9 vs. 53.1 ± 15.8, $p = 0.004$). The age at death was younger in Hispanics than in non-Hispanics (46.5 ± 15.6 vs. 53.0 ± 15.8; $p < 0.05$).

Among those professional firefighters who died, the mean age at first certification was 37.1 ± 10.7 years; the average length since certification was 15.5 ± 7.5, and the mean age at death was 53.1 ± 14.2 (Table 4.2). Women firefighters had a significantly shorter length of certification than men firefighters (11.3 ± 7.1 vs. 15.6 ± 7.5) ($p < 0.001$). Hispanics also had a significantly shorter length of certification than non-Hispanics (10.3 ± 7.5 vs. 14.3 ± 8.6, $p < 0.001$).

The number and proportion by cause of deaths in men and women professional firefighters and volunteers as well as gender- and cause-specific mortality proportions for general the Florida population are listed in Table 4.6. The cause of death was distributed similarly among male professional firefighters and volunteers. The major causes of death for both male professional firefighters and volunteers were circulatory diseases (professional firefighter: 390/1,411 [28%]; volunteer: 322/1,095 [29%]), malignant neoplasm (404 [29%]; 296 [27%]), and external causes including but not limited to motor vehicle accidents and suicide (269[19%]; 190 [17%]). Compared to the general Florida male population, men firefighters had greater proportions of death due to cancer (29% vs. 23%) and external causes (19% vs. 8%), and a lower proportion of death due to circulatory diseases (28% vs. 44%).

There was greater variation in the female mortality pattern. Among the women professional firefighters, 34% (13/38) died of circulatory diseases compared to 18% (17/95) of the women volunteers and 46% of the general Florida female population. In addition, higher proportion of the women professional firefighters died of external causes (9 [24%]) compared to the women volunteers (13 [14%]) and the general Florida female population (4%). However, a high proportion of women volunteers died of malignant neoplasm (39 [41%]) compared to women professional firefighters (8 [22%]); the latter percentage was similar to the proportion observed in the general Florida female population (22%).

4.2. Standardized Incidence Ratio (SIR) for Cancer

4.2.1. Cancer SIR in Male Professional Firefighters

A total of 970 cancer incidence cases were identified among 35,777 males with 413,022 person-years. Using the corresponding cancer incidence rates obtained for the general Florida population, with adjustment for age, sex, and calendar year, the SIR results for male professional firefighters are shown in Table 4.7. Cancer risks for bladder (1.29; 1.01-1.62), testes (1.60; 1.20-2.09), and thyroid (1.77; 1.08-2.73) were significantly increased in male professional firefighters. Eye cancer (2.54; 0.42-3.95) in male firefighters was increased, but the increase was not statistically significant. Significantly decreased cancer risks were found for cancers of all sites combined (SIR = 0.84; 95% CI = 0.79-0.9), brain (0.58; 0.31-0.97), buccal (0.67; 0.47-0.91), lung (0.65; 0.54-0.78), stomach (0.50; 0.25-0.90), and lymphopoietic system (0.68; 0.54-0.85).

4.2.1.1. Cancer SIR in Male Hispanic Professional Firefighters

There were 33 (3.4% of male cancer cases) cancer incidence cases identified among 3,983 male Hispanic professional firefighters with 24,439 person-years. Because of the small number of incidence cases, SIR estimates for male Hispanic firefighters had wide confidence intervals. The overall cancer risk for male Hispanic firefighters was not significantly decreased (0.72; 0.50-1.02). Increased risks were found for colon cancer (1.79; 0.48-4.59), Hodgkin's disease (2.63; 0.30-9.50), and pancreas cancer (3.39; 0.38-12.24), but none of the cancer risks for Hispanic male firefighters was statistically significant (Table 4.8).

4.2.1.2. Cancer SIR in Male Non-Hispanic Professional Firefighters

Because the majority of male professional firefighters were non-Hispanic, the cancer risk pattern for male non-Hispanic firefighters was similar to that of all male firefighters (Table 4.9). There were 937 (96.6% of male cancer cases) cancer incidence cases found among male non-Hispanic firefighters with 388,583 person-years. Overall cancer risk was significantly decreased (0.82; 0.76-0.87). Testes cancer, however, was increased (1.57; 1.18-2.05). Also decreased were the risks for cancer of the brain (0.55; 0.29-0.94), buccal (0.66; 0.47-0.90), digestive system (0.73; 0.62-0.86), lung (0.62; 0.52-0.74), pancreas (0.47; 0.23-0.87), and stomach (0.52; 0.26-0.93).

4.2.2. Cancer SIR in Male Professional Firefighters Certified between 1972 and 1976

As with the mortality data, the majority of cancer incidence cases occurred in the early cohort of male firefighters. Over 686 (70%) of all cases were among the firefighters certified between 1972 and 1976, and this subcohort contributed 145,031 (29%) of all person-years for the whole cohort. SIR results in this cohort are shown in Table 4.10. The overall cancer risk (0.99; 0.92-1.07) was no longer decreased, but rather similar to the general population. In this sub-cohort, however, risks for a few cancer sites were significantly increased; these sites included: bladder (1.49; 1.13-1.94), colon (1.47; 1.13-1.87), prostate (1.35; 1.15-1.56), and skin (1.61; 1.22-2.08). Lung cancer (0.77; 0.63-0.94) was still significantly lower in these firefighters relative to the general Florida population.

4.2.3. Cancer SIR in Female Professional Firefighters

Fifty-two cancer incidence cases were identified among the 2,165 women professional firefighters with 18,843 person-years (Table 4.4). The SIR results are shown in Table 4.11. The overall cancer risk was significantly increased in women professional firefighters (1.63; 1.22-2.14). Cancer risks were also significantly increased in women firefighters for Hodgkin's' disease (6.25; 1.26-18.26) and thyroid cancer (3.97; 1.45-8.65). Higher risks of colon (2.27; 0.26-8.21), rectum (5.26; 0.07-29.28), stomach (5.56; 0.07-30.91), and kidney (4.17; 0.05-23.18) cancer were observed, but the increases were not statistically significant. There were no cases found of the female-endocrine cancers (including breast, cervix, and uterus) among the women firefighters.

4.3. Standardized Mortality Ratio (SMR) for Cancer Deaths

4.3.1. Cancer SMR in Male Professional Firefighters

The overall and site-specific cancer SMRs for male professional firefighters based on 403 cancer deaths are presented in Table 4.12. Using the general Florida population as the comparison, significantly reduced mortality risk was observed in professional firefighters for overall cancer (0.85; 0.77-0.94). Significantly increased mortality risks among men professional firefighters were found for male breast cancer (7.41; 1.99-18.96) and thyroid cancer (4.82; 1.30-12.34). The mortality risk for bladder cancer (1.79; 0.98-3.00) was insignificantly increased; however the mortality risk for lung cancer in professional firefighters was similar to the general Florida population (0.93; 0.79-1.09), and cancers of buccal/pharynx (0.42; 0.17-0.87) and pancreas (0.57; 0.29-0.99) were significantly decreased. There was no excess mortality from brain tumor (0.66; 0.35-1.13), prostate cancer (1.08; 0.67-1.65), kidney cancer (0.60; 0.24-1.23), and other sites.

4.3.2. Cancer SMR in Male Professional Firefighters (Certified between 1972 and 1976)

The SMR results for the early cohort are shown in Table 4.13. Compared to the full cohort, neither the mortality risk for overall cancer (0.89; 0.80-1.00) nor for thyroid cancer (4.76; 0.96-13.91) reached statistical significance. The early cohort had a significant excess mortality risk for bladder cancer (1.95; 1.04-3.33). There were increased but not significant excess mortality risks for colon (1.22; 0.84-1.72) and skin (16 of 17 deaths were malignant melanoma of the skin cancer, ICD-9 = 172; ICD-10 = C43) (1.21; 0.68-2.00) cancer. The significantly lower mortality risk for buccal/pharynx cancer was again observed in the early cohort of male professional firefighters (0.38; 0.12-0.89). There were decreased, but not significant, mortality risks for cancers of the brain (0.62; 0.27-1.23), esophagus (0.55; 0.22-1.14), and kidney (0.43; 0.12-1.11).

4.3.3. Cancer SMR in Female Professional Firefighters

Because of the small number of cancer deaths (n = 8) in women professional firefighters, the SMR estimates were unstable, with wide confidence intervals (Table 4.14). There were no significant excesses or decreases, either for overall cancer (1.03; 0.44-2.03) or for any site-specific cancer including breast (0.51; 0.01-2.82), lung (2.22; 0.45-6.49), and lymphopoietic (1.25; 0.02-6.95).

4.4. Standardized Mortality Ratio (SMR) for Non-Cancer Deaths

4.4.1. Non-Cancer SMR in Male Professional Firefighters

Using the general Florida population as the comparison, with adjustment for age, sex, and calendar year, the SMR results for all known non-cancer mortality causes as well as for a selection of specific mortality causes are shown in Table 4.15. Among 1,411 deaths identified in the cohort of 35,777 male professional firefighters, there were 62 (4.5%) deaths whose causes were unknown. There were 914 (66.3%) non-cancer deaths and 403 (29.2%) cancer deaths. The overall mortality risk was significantly lower among professional firefighters than the general Florida population (SMR = 0.57; 95% CI =

0.54-0.60). The risks for all non-cancer causes (0.50; 0.47-0.53), infectious diseases (0.16; 0.11-0.22), allergic/endocrine diseases (0.35; 0.22-0.52), circulatory system diseases (0.69; 0.63-0.76), respiratory diseases (0.50; 0.35-0.70), digestive diseases (0.57; 0.43-0.73), genitourinary diseases (0.38; 0.14-0.83), and external causes (0.45; 0.40-0.50) were also significantly decreased compared to the Florida population. Of note, there was no risk for any non-cancer mortality cause that was significantly elevated among the professional firefighters compared to the Florida population.

4.4.2. Non-Cancer SMR in Male Professional Firefighters (Certified between 1972 and 1976)

Because nearly three-quarters (n = 1,003; 74.9%) of all deaths and 216,539 person-years (43% of total person-years) occurred in the subcohort of firefighters certified between 1972 and 1976, and there was a sufficient lapse of time to allow for the development of cancer from occupational exposures, separate SMRs were calculated for the subcohort (Table 4.16). The results were similar to those obtained for the full cohort. The overall mortality risk (0.68; 0.64-0.73) as well as mortality risks for the following diseases were significantly lower among the sub-cohort firefighters than the general Florida population: infectious (0.24; 0.14-0.37), allergic/endocrine (0.39; 0.22-0.63) including diabetes (0.43; 0.21-0.76), circulatory system (0.73; 0.66-0.81), digestive (0.71; 0.53-0.93), respiratory (0.60; 0.41-0.86), and mental (0.56; 0.29-0.98) disease and external causes (0.51; 0.43-0.61). The mortality risk for blood (1.33; 0.48-2.89) and genitourinary (0.52; 0.19-1.13) disease in the subcohort firefighters was not significantly different from the general Florida population. No increased mortality risk was found for any non-cancer mortality causes.

4.4.3. Non-Cancer SMR in Female Professional Firefighters

Thirty-eight deaths (1.8%) occurred among 2,165 female professional firefighters, including 30 (78.9%) non-cancer deaths and 8 (21,1%) cancer deaths. Unlike their male colleagues, mortality risk was significantly elevated in female firefighters for circulatory system diseases (2.49; 1.32-4.25). The mortality risks in women firefighters for the respiratory diseases (2.88; 0.58-8.43) and suicide (2.52; 0.68-6.44) were insignificantly elevated. Neither the overall risk (1.24; 0.87-1.70), nor the non-cancer mortality risk (1.38; 0.93-1.97) and any specific cause of mortality risk was significantly reduced in women firefighters relative to the general female Florida population (Table 4.17).

4.5. Proportional Mortality Ratio (PMR) for Cancer Deaths

4.5.1. PMR for Cancer Deaths in Male Professional Firefighters

There were 404 cancer deaths in the cohort of male professional firefighters. Using the general Florida population as the comparison group, the cancer PMR results for men professional firefighters are given in Table 4.18. Overall, the mortality ratio for all-site combined cancer was significantly elevated compared to the general Florida population (1.19; 1.07-1.30). The mortality ratios for colon cancer (1.54; 1.05-2.03), lung cancer (1.30; 1.10-1.52), bladder cancer (2.11; 1.01-3.22), and male breast cancer (186; 3.72-368) were significantly increased, but the result for the male breast cancer was based on only 4 deaths. The mortality ratios for skin, brain, lymphopoietic, sarcoma, and prostate cancer were also increased, but the increases were not statistically significant. Only the Hodgkin's disease mortality ratio was significantly decreased (0.10; 0.00-0.30); the buccal/pharynx cancer mortality ratio in male firefighters was decreased, but this association did not reach statistical significance (0.66; 0.17-1.15).

4.5.2. PMR for Cancer Deaths in Male Volunteers

There were 296 cancer deaths in the cohort of volunteers. The overall cancer mortality ratio (Table 4.19) was slightly increased, but not statistically significant in the volunteers (1.12; 0.99-1.25). Compared to the general Florida population, the mortality ratios for lung cancer (1.29; 1.05-1.53) and leukemia (1.96; 1.18-2.75) were significantly elevated; and similar to the professional firefighters, the mortality ratio for Hodgkin's disease was significantly decreased (0.13; 0.00-0.39).

4.5.3. PMR for Cancer Deaths in Female Professional Firefighters and Volunteers

Only 8 cancer deaths were identified in the female professional firefighters, while 39 cancer deaths were identified in the female volunteers. Site-specific mortality ratios analyses were not conducted because of the small numbers. The overall cancer mortality ratio was slightly lower in the female professional firefighters (0.89; 0.27-1.51), but was elevated in the female volunteers (1.43; 0.98-1.88); both differences were not statistically significant.

4.6. Proportional Mortality Ratio (PMR) for Cancer Deaths Using the Volunteers as Comparison (Males Only)

Compared to the volunteers (Table 4.20), the overall cancer mortality ratio was slightly higher in the professional firefighters (1.06; 0.96-1.16). Compared to the volunteer firefighters, the professional firefighters also had a significantly higher mortality ratio for colon cancer (1.52; 1.04-2.01) and a lower ratio for rectal cancer (0.56; 0.15-0.98). Higher but not statistically significant mortality ratios were also observed for cancers of buccal/pharynx (1.23; 0.32-2.14), bladder (1.79; 0.85-2.73), brain (1.14; 0.52-1.76), lymphopoietic system (1.06; 0.74-1.39), and male breast cancer (4.39; 0.09-8.70), but lower ratios in skin, sarcoma, kidney, and prostate cancer than the volunteers; none of these PMRs was statistically significant.

4.7. Proportional Mortality Ratio (PMR) for Non-Cancer Deaths

The PMR analyses were conducted separately for the professional firefighters and for the volunteer firefighters by gender. All data were adjusted for age in 5-year increments; disease was categorized using the ICD-9. The PMR analyses were first performed comparing each firefighter group to the general Florida population and then separately comparing the professional firefighters to the volunteer firefighters.

4.7.1. PMR for Non-Cancer Deaths in Florida Male Professional Firefighters

Using the general Florida population as the comparison group, the PMR results for non-cancer deaths in Florida male professional firefighters are presented in Table 4.21. Overall, there were 1,411 deaths among the 35,777 male professional firefighters. The proportions of deaths due to allergic/endocrine diseases (PMR = 0.59; 95% CI = 0.33-0.86), circulatory system diseases (0.85; 0.76-0.93), respiratory diseases (0.18; 0.12-0.24), digestive diseases (0.40; 0.30-0.51), and genitourinary diseases (0.54; 0.11-0.97) were all significantly lower compared to the general Florida population. The mortality proportions for external causes, infectious diseases (tuberculosis, in particular), and blood diseases were slightly higher in the male professional firefighters, but these differences were not statistically significant.

4.7.2. PMR for Non-Cancer Deaths in Male Florida Volunteers

Overall, 1,095 deaths were identified among the 29,218 men volunteers. The non-cancer death pattern in volunteers was similar to that in the professional firefighters (Table 4.22). The mortality proportions in circulatory system diseases (0.86; 0.77-0.96), respiratory diseases (0.19; 0.12-0.27), digestive diseases (0.22; 0.13-0.32), and genitourinary diseases (0.30; 0.00-0.63) were significantly lower than that of the general Florida population. Slight but not statistically significant increases in the mortality proportions were observed for diseases of blood, nervous system diseases, and suicide. The mortality ratio in motor vehicle deaths was significantly increased in the volunteer firefighters (1.27; 1.00-1.54).

4.7.3. PMR for Non-Cancer Deaths in Female Florida Professional Firefighters

Among 2,165 female professional firefighters, 38 deaths occurred. The results of PMR for non-cancer are presented in Table 4.23. Significantly lower mortality ratios were observed for circulatory diseases (0.32; 0.15-0.50) and digestive diseases (0.27; 0.00-0.87). The mortality proportions of emphysema (5.01; 0.00-14.82), pneumonia (3.62; 0.00-8.64), suicide (2.46; 0.05-4.86), and AHD (1.70; 0.52-2.87) were also increased but not statistically significant; in addition, these results were based on a few deaths (0-4 deaths).

4.7.4. PMR for Non-Cancer Deaths in Female Florida Volunteers

Using the general Florida population as the comparison group, the non-cancer PMR results for female volunteers are shown in Table 4.24. A total of 95 deaths were identified in the 5,628 female volunteers. Similar to the professional female firefighters, mortality proportions for circulatory system diseases (0.16; 0.09-0.24) and digestive diseases (0.45; 0.01-0.88) were significantly lower in female volunteers than in the general Florida population. In addition, the respiratory diseases mortality proportion was also significantly lower in the women volunteers (0.23; 0.00-0.55). There were no significant differences in mortality ratios for all other non-cancer deaths, although there were increases in mortality ratios for infectious diseases deaths (3.29; 0.07-6.51), emphysema (5.01; 0.00-14.8), and diseases of blood (1.93; 0.00-5.72).

CHAPTER FIVE: CONCLUSIONS

This chapter discusses the results presented in the previous chapter in relation to study hypotheses, compares them with findings from previous firefighter investigations, discusses the strengths and data limitations of this study, and presents the study's overall conclusions.

5.1. 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.

5.1.1. 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.

5.1.2. 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.

5.2. Discussion in Relation to Study Hypotheses

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.

5.2.1. 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.

5.2.2. 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.

5.2.3. 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.

5.2.4. 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.

5.3. Discussion of Other Findings

5.3.1. Female Professional Firefighters

Only a relatively small number of women firefighters were present in the cohort. The SIR result showed significant increases in overall, kidney, and thyroid cancer incidence among female firefighters. In addition, the SMR results showed a significantly elevated mortality excess from circulatory system diseases among female firefighters.

These findings are different from what were found among men professional firefighters; the differing results might be due to gender differences in the level of occupational exposures (or confounding factors) and/or to different responses to certain toxic agents between male and female firefighters, or simply due to chance. In addition, because women on average are smaller in size, it is possible that the dose of carcinogen exposures per body weight was greater in women than that in men.

In recent decades, research on occupational exposures has focused predominantly on men (Pottern et al., 1994), neglecting female workers because of insufficient numbers to provide meaningful results (Arena et al., 1999). To date, there is no available literature on the health effects of firefighting in women firefighters, even though increased risks with selected cancers among other female workers have been reported in a number of professions. For example, leukemia has been reported to be elevated among women employed in health-care professions (Linet et al., 1994; Skov et al., 1992; Burnett and Dosemeci, 1994), and lung cancer elevation has been found among women with potential exposure to asbestos through jobs in assembly of gas masks and textiles (Botta et al., 1991; Rosler et al., 1994).

We are not aware of any human data that clearly demonstrate that an established carcinogen causes different non-reproductive cancers in men and women. Therefore, it is not likely that the discrepancy in cancer risk patterns between male and female firefighters was due to gender-specific responses to carcinogens. However, some epidemiological data suggest that the potency of certain carcinogens may vary by gender; several studies have found a greater risk of lung cancer in women from tobacco use than men (Brownson et al., 1992; Prescott et al., 1998). Unfortunately, information on firefighting exposure and life style variables (e.g., tobacco use, drinking, physical activities) is not available, precluding our addressing the issue. Gender differences in levels of exposure are also a concern. There are several components to gender-based exposure differences within occupation. These include different assignment of job tasks based on gender, gender-specific approaches to performing the same tasks, and gender differences in the use of protective equipment (Blair et al., 1999). Gender difference in the HWE has also been reported. Using data from the 1960 and 1970 Swedish censuses, Gridley et al (1999) found that women employed in both 1960 and 1970 had increased overall cancer incidence; they concluded that there was no general HWE for cancer incidence among employed Swedish women.

As with many epidemiological studies of occupational cancer among women, our data were insufficient to compare cancer risks from occupational exposures by gender. We could not explain what might have caused the discrepancy found in the present study between male and female firefighters. We recommend caution in interpreting our findings in female firefighters due to their small numbers and their relatively recent entry into this profession.

5.3.2. Hispanic Male Professional Firefighters

Both Hispanic men and women in Florida have been shown to have significantly lower overall cancer incidence (Wilkinson et al., 2002a; Wilkinson et al., 2002b), probably due to their dietary and obesity patterns and/or genetic composition. The present analysis did not find any significant increased cancer incidence risk for male Hispanic firefighters, in part, due to the small sample size. Again, caution is warranted in the interpretation of our findings in Hispanic firefighters.

5.3.3. Cardiovascular Disease Mortality

The present study did not find an increased risk of cardiovascular disease mortality in firefighters. The association between heart diseases and firefighting has been inconsistent, mainly because of a number of methodological problems, including the HWE (Choi, 2000). In his 1995 review, Guidotti concluded that the evidence of an increased mortality risk in firefighters was inconclusive. The limitation of current methodology for the conduct of occupational mortality studies makes it difficult to determine the extent of the increased risk for cardiovascular disease mortality in firefighters. The HWE hinders the clear interpretation of study findings and the comparison of different studies (Melius, 1995). In a recent article, Choi (2000) reviewed 23 studies and reassessed the association between firefighting and heart disease in light of the HWE. He used a new technique that takes into account study design, specific cause of death under study, type of occupation, type of comparison group, magnitude of an all-cause SMR or similar statistics that may indicate the extent of the HWE, workers' inclusion criteria based on length of employment, follow-up period, all-cause SMR or similar statistics greater than unity, magnitude of SMR in relation to SPMR or SMOR, and sample size. After reassessment, he found that 11 studies showed positive evidence and 16 showed no evidence; he concluded that there is strong evidence of an increased risk of death overall from heart disease in firefighters. Given the facts that firefighters are exposed to high levels of carbon monoxide (a known cardio-toxic substance) at the fire scene as well as tremendous psychological stress and physical demands (Pfefferbaum et al., 2002), further studies are needed that are designed to control for the HWE (such as a case-control study or a cohort study with internal comparisons) of cardiovascular diseases and firefighting.

5.3.4. Proportional Mortality Ratio Analyses

Compared to the general Florida population, male professional firefighters had significantly lower proportionate mortality for allergic/endocrine, circulatory system, respiratory, digestive, and genitourinary diseases; men professional firefighters had significantly higher proportionate mortality for overall cancer, digestive cancer, respiratory cancer, and male breast cancer.

Male professional firefighters had no significant increase or decrease in overall or site-specific proportionate cancer mortality as compared to the male volunteers. However, proportionate mortality for colon cancer was significantly increased (PMR = 1.52; 95% CI = 1.04-2.01); there was also noticeable increase in proportionate mortality for bladder cancer, but it was not statistically significant (PMR = 1.79; 95% CI = 0.85-2.73).

For female professional firefighters, significantly lower proportionate mortality was observed for circulatory diseases and digestive diseases. The overall proportionate cancer mortality was slightly lower in the women professional firefighters compared to the general Florida population.

The non-cancer death pattern in male volunteers was similar to that for male professional firefighters. Mortality proportions in circulatory system, respiratory, digestive, and genitourinary diseases were significantly lower than those of the general Florida population. The overall proportionate cancer mortality was slightly increased, but was not statistically significant; only the proportionate mortality for respiratory cancer was significantly elevated in the male volunteers.

For women volunteer firefighters, mortality proportions for circulatory system, respiratory, and digestive diseases were significantly lower compared to the general female Florida population.

5.3.5. Discrepancy between PMR and SMR Results

Both PMRs and SMRs are commonly used in occupational epidemiological studies as measures of differential mortality risks. The SMR is chosen when the age, gender (or race) of the population-at-risk are known. It provides information on a study group's general mortality risk as well as risks for specific causes of death. The PMR is often used to approximate SMR when the available data consist only of deaths.

There have been various theoretical and empirical comparisons between the PMR and SMR as effect measures of occupational exposures on mortality (Breslow et al., 1987; Redmond and Breslin, 1975; Kupper et al., 1978; Zeighami and Morris, 1983). DeCoufle et al. (1980) have demonstrated that, theoretically, a mathematical equation can be established to describe the relationship between the PMR and SMR, that is: PMR equals SMR multiplied by a factor which is the ratio of overall death rates in the referent population to that in the occupational group. So if, and only if, the overall death rates in the comparison population are equal to the rates in the occupational group will the results of PMR and SMR be the same. Because of the HWE, as discussed before, occupational populations generally have a significantly lower overall mortality rate than the general population. Therefore, the estimates of PMR are usually greater than the estimates of

SMR. This conclusion has been substantiated by many empirical comparisons (Walter, 1986) and is demonstrated in the present study.

There were differences between PMR and SMR results in the present study. In general, PMR estimates were greater than SMRs for the same disease. For example, the lung cancer PMR was greater than lung cancer SMR in the professional firefighters. This discrepancy was not unexpected because many studies (as well as this study) have shown that the overall mortality rate was significantly lower in firefighters than in the general population. Because the PMR is used as an approximation to the SMR and in light of the HWE in the firefighter population, the SMR findings are preferable to the PMR findings for this study.

The PMR findings using the volunteer firefighters as a comparison, however, were unlikely to be affected by the HWE. These PMR estimates would be closest to the SMR results. Although it is possible that volunteer firefighters were also exposed to fire environments, the exposure level was undoubtedly lower compared to the professional firefighters. The PMR findings that male professional firefighters had significant excess mortality for colon cancer, noticeable but not statistically significant excess mortality for bladder cancer, consistent with the SMR and SIR results, was worth noting, further indicating that the excesses in colon and bladder cancer in professional firefighters were most likely due to their occupational exposures.

5.4. Strengths and Limitations of the Study

5.4.1. Summary of Study Strengths

This study is the largest firefighter study to date in terms of the number of firefighters included in the analyses and with respect to the total follow-up person-years.

It is also the first study to examine the mortality and cancer risk in women firefighters as well as in male Hispanic firefighters. It is the second study that used cancer incidence data. This study also had a comparison group of volunteer firefighters. Unfortunately, the absence of cohort entry dates for the volunteers limited their use as a comparison group to only the PMR analyses.

5.4.2. Limitations

Despite the demonstrated strengths of this study, several data limitations could not be overcome. As seen in many previous epidemiological studies of firefighters, information on potential confounders, such as cigarette smoking and family history of cancer, was not available for this cohort. Additional limitations include issues of the HWE, loss to follow-up, and relatively short follow-up time.

The use of the Florida general population as the comparison population was appropriate for geographic and logistic reasons. However, in occupational studies, the use of a general population as a comparison population inherently raises the issue of the HWE (Checkoway et al., 1989; Monson, 1990; Breslow et al., 1987; Arrighi and Hertz-Picciotto, 1993; Howe et al., 1990; Choi and Noseworthy, 1992). The use of a comparison worker population when it is available is always preferable; for this reason, the volunteer firefighters were used as a comparison population in the PMR study. However, the lack of entry dates for the volunteers meant that follow-up time could not be estimated for them, which thus eliminated them as the comparison in SMR and SIR analyses. Furthermore, volunteer firefighters are likely to be exposed to carcinogens, making them a poor "unexposed" group.

The HWE is a type of bias (Choi et al., 1992) defined as "an observed decrease in mortality in workers when compared with the general population" (Choi, 1992). A HWE could be due to healthy individuals being more likely than unhealthy persons to seek and gain employment and to remain in their jobs. The effect is amplified by the stringent initial job screening process and good employment benefits associated with employment as a firefighter, as evidenced by their low overall mortality rate (Golden et al., 1995). The HWE has been demonstrated to have less impact on cancer than on other causes of death due largely to the long latency and low incidence of cancer (Choi et al., 1992); the effect often dilutes or masks associations between occupational exposures and cancer and is less likely to create falsely positive associations. Of note, given the use of the Florida general population as the major comparison population, significantly elevated risks for the firefighters should be given added weight.

Lack of information on potential individual confounders such as tobacco use is another limitation of this study. However, in studies of occupation and cancer that did collect information on lifestyle factors among firefighter populations, most associations remained unchanged after controlling for cigarette smoking (Axelson and Steenland, 1988; Dubrow and Wegman, 1983). The vast majority of studies found no excess risk of lung cancer; this agreement of results suggests that firefighters are not more likely to smoke than the general population or other protective service workers. In fact, surveys have found that the proportion of firefighters who smoke is similar to the proportion of other service and blue-collar workers who smoke (Bates, 1987; Sama et al., 1990). In addition, the effects of tobacco use in the study population can be evaluated by the so-called tobacco-exposure cancer profile (i.e., increased lung, larynx, bladder, cervical, and other cancers as a group); an increased tobacco-exposure cancer profile is expected if the occupational group under study has a higher level of tobacco use than the comparison group. This tobacco-exposure cancer profile is not found in this Florida firefighter cohort.

A major limitation of this study is that no direct exposure measures were available; certification was used as a surrogate measure for fire exposure. As a result, heavily exposed firefighters may have been mixed with lightly exposed firefighters. Thus the risks to the heavily exposed firefighters could have been diluted out and underestimated by the design of the study due to misclassification bias. Misclassification could also be introduced by the use of certification as the surrogate measure of fire exposure; some certified firefighters might no longer be engaged in active firefighting. This misclassification may lead to overestimation of firefighting exposures. The lack of individual exposure information is an important limitation on the conclusions that can be drawn from the findings of this study. Furthermore, this study analyzed data occurring over several decades. Because of the lack of information on 1) changes in diagnosis, 2) differences in exposure over time (i.e., many potential carcinogens, such as chemicals and synthetic materials, were introduced at different times during the relevant exposure periods), 3) changes in protective equipment and awareness of hazards, and 4) lack of information on the second job exposures [because of the 24 hour shifts and 11 days a month schedule, about three-quarters of firefighters have some kind of second job (http://www.press-citizen.com/progress2001/morning-insuranceagent.htm), many work in construction that may be exposed to solvents and other carcinogens], these important confounding issues can not be addressed in the present study.

As discussed in Chapter Three, date-of-birth information was not available for 6,495 (8.7% of all firefighters/volunteers) subjects in the cohort (2,272 or 5.8% of professional firefighters and 4,671 or 11.5% of volunteers); this information was not found through the multiple data linkages performed. It appeared that the firefighters certified earlier were more likely to be lost to follow-up; 47% (1,240) of the lost-to-follow-up group were certified before 1980 versus 32% (11,944) of those whose information was available ($p < 0.001$). Nevertheless, these persons were ultimately excluded from our master study database cohort because date-of-birth information was essential for the statistical analyses performed. The loss of these persons to the cohort may lead to an underestimate (or overestimate) of risk, and represent an important limitation to our findings and conclusions.

Although this study is the largest firefighter study to date, the cohort was relatively young. Many cancers have a long latency; some of these cancers are yet to emerge in our cohort because of insufficient follow-up time. This is evident as the overall professional firefighters entered cohort at an average age of 28 (± 7) (i.e., age at first certification, see Table 4.3), significantly younger than those who had cancer (35 ± 9) or those who died (37 ± 11). The older age at first certification for cancer incidence or general mortality was largely due to that many of these professional firefighters were already in service when the certification was first started in 1972, thus had the longest follow-up time in the cohort. For this reason, we performed additional SMR/SIR analyses restricted to professional firefighters certified between 1972 and 1976. Results from this subcohort analyses were less likely to be affected by the short-follow-up-time limitation.

5.4.3. Additional Comments

The study originally proposed two other data linkages with the firefighter database that were not realized. One of the linkages was with the ChoicePoint Nationwide Death Search, for the purpose of limiting the number of missing values due to loss to follow-up; this linkage was not done due to budgetary constraints. The impact of this unrealized opportunity, however, should be minimal, because with all the linkages conducted, the loss to follow-up rate was 8.7%, an acceptable level. It was also not possible to perform the data linkage with state pension records due to lack of access to these data. This database was to be the source for data on the start dates for the volunteers and end dates for the professional firefighters. Without this information, the investigators were not able to perform logistic analyses (or Poison regression) to assess possible dose-response relationships by comparing cancer incidence/mortality risk among subcohorts of firefighters with varying lengths of certification time as a firefighter. Another reason that the logistic analyses were not performed as proposed was because of the difficulty in identifying subgroups among professional firefighters. We originally considered using information on certification type to categorize the professional firefighters into subgroups, but the data on certification type turned out to be incomplete and unrelated to the exposure, according to the Florida Fire College. Nevertheless, because the firefighter database contained unexpected information on the volunteer firefighters, the investigators performed additional PMR analyses using volunteer firefighter group as a peer comparison, thus allowing for an assessment of the potential HWE in this study.

5.5. Conclusions

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.

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TABLES

Table 2.1. Firefighter Work Process

A. General	Organization, structure, rules, and regulations of the fire department; completion of reports and documentation of fire department records
B. Forcible Entry	Use and maintenance of tools and equipment; methods and procedures through doors, windows, ceiling, roof, floor or vertical barrier
C. Protective Breathing Apparatus	Use of equipment in various hazardous environments; maintenance of equipment, recharging of breathing apparatus; correct use of emergency procedures to assist others
D. First Aid	Demonstrate conducting first aid practices for life-threatening injuries on a victim; demonstrate conducting first aid practices for other than life-threatening injuries on a victim; standard operating procedures, search and rescue, extrication, prehospital emergency care, triage, disaster plans and procedures, drive and operate
E. Ropes	Identify and produce by tying a bowline knot, a clove hitch, becket or sheet bend, bight, loop, round turn, and half-hitch; hoist equipment, inspect, clean, and maintain rope; select and use rope of appropriate size, strength, and length for various tasks
F. Salvage	Proper use, inspection, cleaning, and maintenance of salvage equipment
G. Fire Hose, Nozzles, and Appliances	Identify hose, hose adapters, and hose appliances; advance dry hose lines or charged attack lines; clean and inspect hose, couplings, and nozzles; hose rolls, hose carriers, loading of hose on fire apparatus; hydrant/pumper connections; testing of fire hose
H. Fire Streams	Use nozzle to attack a class A and class B fire; properly open and close a nozzle; select proper hose size and nozzle; use foam-making appliances; select proper adaptors or appliances
I. Ladders	Identify various ladders; carry ladders individually or as a member of a team; raise ladder; ascend and descend ladders with tools, with injured person; inspection, cleaning, maintenance, and testing of ladders
J. Ventilation	Opening various types of windows and doors; ventilation of a roof or floor; use and care of power saws and other equipment; size openings for ventilation; remove skylights, scuttle covers, etc.

Continuing Table 2.1. Firefighter Work Process

K. Inspection	Procedures for inspections of buildings and exit drill procedures; identify common fire hazards and make recommendations for their correction; inspect fire extinguishers, standpipe systems, sprinkler systems, private water systems, detection alarm systems, electrical services and appliances, chimneys and flues, storage of flammable liquids and gases; storage of materials to ensure proper piling, aisles, clearances, and access to fire equipment and exits
L. Rescue	Use of carriers, drags, and stretchers; use of life belt and life net; search for victims in hostile environments; use of rescue tools; extrication of a victim from a vehicle
M. Sprinklers	Operation of main drain and main control valves; maintain sprinkler systems; test sprinkler systems; read and record pressures on all gauges
N. Fire Alarms and Communication s	Receive alarm or report of emergency and initiate proper action; identify all fire alarm signals and action to be taken upon receipt of each signal; proper use of radio equipment; resetting of alarm devices
O. Safety	Use of all firefighting equipment and apparatus; safety equipment used in electrical emergencies; recognition of symbols used to designate hazardous material and areas; general safety precautions
P. Fire Behavior	Chemistry of fire, flame spread flashover, phases of burning, classes of fires and heat transfer; fire-suppression agents
Q. Water Supplies	Operation, maintenance, and use of water distribution systems including hydrants, water pressure, main valves, discharge capacities, and piping
R. Portable Extinguishers	Identify and distinguish between different types of extinguishers; operation, inspection, and testing
S. Overhaul	Methods and procedures to detect and extinguish hidden fires; procedures for overhaul of building and its contents

*From (http://www.grand.k12.ut.us/cash/wps/FIREFGHT.htm International Fire Service Training Association 1998)

Table 2.2. Products of Combustion of Common Materials*

Combusted Material	Fuel Component of Original Material	Toxic Decomposition Products*
wood, paper, cotton, jute	cellulose	aldehydes, acrolein
clothing, fabric, blankets, furniture	wool, silk	hydrogen cyanide, ammonia,hydrogen sulfide
tires	rubber	sulphur dioxide, hydrogensulfide, methyl mercaptan, benzene-related compounds
upholstery material, wire, pipe coating, wall, floor, furniture coverings	polyvinyl chloride	hydrogen chloride, phosgene
insulation, upholstery material	polyurethane	hydrogen cyanide, isocyanates oxides of nitrogen
clothing, fabric	polyester	hydrogen chloride
upholstery material, carpeting	polypropylene	acrolein
appliances, engineering plastics	polyacrylonitrile	hydrogen cyanide, ammonia oxides of nitrogen
carpeting, clothing	polyamide (nylon)	hydrogen cyanide, ammonia oxides of nitrogen
household and kitchen goods	melamine resins	hydrogen cyanide, ammonia, formaldehyde, oxides of nitrogen
aircraft windows, textiles	acrylics	acrolein
kitchen goods, electrical insulation, gaskets	polytetrafluor-ethylene	octafluoroisobutylene
photographic film	nitrocellulose	oxides of nitrogen

*Carbon monoxide and carbon dioxide are produced in all cases. Other gases, such as the aldehydes, methane, and low-molecular-weight organic acids, are common in most fires (Guidotti, 1992).

Table 2.3. Previous Firefighters' Study Results for Major Cancer Sites

Authors, Year	Population	Risk Estimate*	Lung	Colon	Rectum	Bladder	Kidney	Brain
	Eastern United States							
Musk et al., 1978	Boston Fire Dept.	SMR	88	n/a	n/a	92	103	86
Dubrow & Wegman, 1984	Massachusetts resident firelighters, 1971-1973	SMOR (on mortality)	86	76	60	110	122	86
Feuer & Roseman, 1986	New Jersey	PMR, NJ state comparisons used here	92	n/a	n/a	n/a	n/a	n/a
Vena & Fieldler, 1987	Buffalo Fire Company	SMR	94 (62-136)	183 (105-297)	208 (83-428)	286 (130-540)	130 (26-380)	236 (86-513)
Sama et al., 1990	Massachusetts cancer registry	SMOR vs. police	130 (84-203)	104 (59-182)	97 (50-188)	211 (107-414)	n/a	152 (39-592)
Massachusetts Dept. Public Health, 1990	Massachusetts resident firefighters	SMOR state	122 (87-169)	120 (80-182)	145 (84-219)	159 (102-250)	n/a	86 (34-215)
Baris et al., 2001	Philadelphia	SMR	113 (97-132)	151 (118-193)	99 (59-168)	125 (77-200)	107 (61-188)	61 (31-122)
	Western United States							
Petersen & Milham, 1977	California state residents	PMR	168	113	48	82	175	90
Milham, 1983	Washington state residents	PMR	105	90	103	233	115	194

Continuing Table 2.3. Previous Firefighters' Study Results for Major Cancer Sites

Authors, Year	Population	Risk Estimate*	Lung	Colon	Rectum	Bladder	Kidney	Brain
	Continuing Western United States							
CA Dept. Health Services, 1987	California, adjusted for presumed rates of smoking, alcohol intake and SES	SMR adjusted	132 (89-190)	131 (48-284)	n/a			n/a
		SMR unadjusted	150 (100-215)	144 (53-314)				
Heyer et al., 1990	Seattle Fire Dept.	SMR	97 (65-139)	79 (32-164)	65 (8-237)	n/a	n/a	95 (20-279)
Rosenstock et al., 1990	Pacific Northwest	SMR vs. US	134 (90-191)	95 (41-187)	119 (44-259)	23 (3-83)	27 (3-87)	210 (131-317)
Beaumont et al., 1991	San Francisco FD	SMR	84 (64-108)	99 (63-147)	145 (77-249)	57 (19-135)	68 (19-174)	81 (26-190)
Demers et al., 1992	Pacific Northwest municipal Fire departments	IDR vs. Police	95 (67-133)	158 (73-343)	89 (30-266)	16 (2-124)	n/a	163 (70-379)
Demers et al., 1994	Seattle & Tacoma	IDR vs. local county	100 (70-130)	110 (70-160)	100 (50-180)	120 (70-190)	50 (10-160)	110 (30-290)
Demers et al., 1994	Seattle & Tacoma	IDR vs. Police	110 (60-190)	130 (60-300)	130 (30-390)	170 (70-430)	40 (10-210)	140 (20-1100)
	Multiple states in the U.S.							
Guralnick, 1963	US census, 1950	SMR to 65 yr	83			n/a	n/a	n/a
Burnett et al., 1984	27 US states	PMR	102 (94-111)	n/a	148 (105-205)	99 (70-137)	144 (108-189)	103 (73-141)
Ma et al., 1998	24 states	MOR	110 (100-120)	100 (90-120)	110 (80-160)	120 (90-160)	130 (100-170)	100 (80-140)

Continuing Table 2.3. Previous Firefighters' Study Results for Major Cancer Sites

Authors, Year	**Population**	**Risk Estimate***	Lung	Colon	Rectum	Bladder	Kidney	Brain
	Outside the Mainland U.S							
Mastromatteo, 1959	Toronto Fire Dept.	SMR	n/a	n/a	n/a	n/a	n/a	n/a
Eliopulos et al., 1984	Western Australian Fire Brigade, 990	SMR	104 (42-213)	159 (43-407)	n/a			n/a
Hansen, 1990	Danish census	SMR vs. civil servants	163 (75-310)	n/a	n/a	n/a	n/a	n/a
Howe & Burch, 1990	Canadian labor-force sample	SMR vs. employed	111 (41-242)	154 (19-556)	n/a	n/a	n/a	0 (0-625)
Grimes, et al., 1991	Honolulu Firefighters	PMR vs. Hawaii population	128 (82-200_	91 (37-220)	n/a	n/a	n/a	378 (122-1171)
Guidotti, 1992	Municipal firefighters in Alberta, Canada	SMR	142 (91-211)			316 (86-808)	414 (166-853)	147 (30-429)
L'Abbe & Tomlinson, 1992	Metro Toronto Fire Depts.	SMR	95 (71-123)	60 (30-108)	171 (91-293)	128 (51-263)	43 (5-156)	200 (109-336)
Tornling et al., 1994	Stockholm Fire Dept.	SMR	90 (53-142)	85 (31-185)	207 (89-408)	31 (1-170)	110 (30-281)	279 (91-651)

Table 3.1. Florida Firefighter/Volunteer Database (N = 79,733)

Field	Available (%)	Missing (%)
SSN	79,732 (100.00)	1 (0.00)
Name	79,733 (100.00)	0 (0.00)
County, State, Zip	33,209 (41.65)	46,524 (58.35)
County Code	79,595 (99.83)	138 (0.17)
Department Code	31,165 (39.09)	48,568 (60.91)
Date of Birth	50,796 (63.71)	28,937 (36.29)
Date of Employment	20,865 (26.17)	58,868 (73.83)
Employment Type	76,894 (96.44)	2,839 (3.56)

Table 3.2. Certification Database (N = 39,455) of Florida Professional Firefighters, 1972–1999

Field	Available (%)	Missing (%)
SSN	39,454 (100.00)	1 (0.00)
Certification Date	39,375 (99.80)	80* (0.20)
Certification Type	34,011 (86.20)	5,444** (13.80)

* Included 25 records with certification date older than 1/1/72 and 277 records with more than one date.

** Not missed but invalid types.

Table 3.3. Employment Data for Firefighters No Longer in Service (N = 23,580)

Field	Available (%)	Missing (%)
SSN	23,580 (100.00)	0 (0.00)
Employment Date	23,230 (98.52)	350 (1.48)
Termination Date	22,024 (93.40)	1,556 (6.60)
Termination Type	22,704 (96.28)	876 (3.72)
Department Code	23,573 (99.97)	7 (0.03)
Unique SSN	19,384 (82.21)	4,196 (17.79)*

* Excluded from the analyses; duplicates occurred because of on/off employment histories.

Table 3.4. Agreement between Firefighter Database and Linked Databases for Date of Birth

Linkage	Appeared in both databases n	Complete agreement n (%)	Difference less than a year n (%)
Motor Vehicles	45,833	44,217 (96.5)	45,084 (98.4)
Death Tapes	1,362	1,164 (85.5)	1,223 (89.8)
FCDS	1,144	1,078 (94.2)	1,114 (97.4)
HCFA	383	350 (82.8)	369 (96.3)

Table 4.1. Gender and Hispanic Ethnicity Distribution in Florida Firefighters/Volunteers

		Male (%)	Female (%)	Total (%)
Professional firefighter	Hispanic	2,462 (95.0)	130 (5.0)	2,592 (7.0)
	Non-Hispanic	32,334 (94.5)	1,887 (5.5)	34,221 (93.0)
	Subtotal	34,796 (94.5)	2,017 (5.5)	36,813
Volunteer	Hispanic	1,521 (84.9)	271 (15.1)	1,792 (5.0)
	Non-Hispanic	28,678 (83.9)	5,505 (16.1)	34,183 (95%)
	Subtotal	30,199 (83.9)	5,776 (16.1)	35,975

Table 4.2. Mean Age at First Certification, Length of Time Certified by Hispanic Ethnicity in Florida Professional Firefighters

	Hispanic	Non-Hispanic	Total	T-test
	Mean ± SD	Mean ± SD	Mean ± SD	p Value
Mean age at first certification	26.6 ± 5.9	28.0 ± 7.0	27.9 ± 7.0	0.001
Mean years certified	10.3 ± 7.5	14.3 ± 8.6	14.0 ± 8.6	0.001

Table 4.3. Mean Age at First Certification, Length of Time Certified by Gender in Florida Professional Firefighters

	Male Mean ± SD	Female Mean ± SD	Total Mean ± SD	t-Test p Value
Entire cohort				
Mean age at first certification	27.9±7.0	28.1±6.4	27.9±7.0	0.17
Mean years certified	14.3±8.6	8.7±5.7	14.0±8.6	0.001
N	34,796	2,017	36,813	
Cancer incidence cases				
Mean age at first certification	35.5±9.1	31.6±7.3	35.3±9.0	0.004
Mean years certified	17.9±7.3	9.0±6.2	17.5±7.5	0.001
N	970	52	1,022	
All deaths				
Mean age at first certification	37.0±10.7	39.5±12.9	37.1±10.7	0.194
Mean years certified	15.6±7.5	11.3±7.1	15.5±7.5	0.006
N	1,349	38	1,387	

Table 4.4. Person Years for Standardized Mortality Ratio Analysis by Age Group and Gender in Florida Professional Firefighters

	Person-Years	
Age Group	Male	Female
SMR Study		
20–39	313,318 (62%)	15,881 (80%)
40–59	169,286 (33%)	3,712 (19%)
60 and above	23,008 (5%)	273 (1%)
Total	505,612	19,866
SIR Study		
20-39	248,870 (60%)	15,283 (81%)
40-59	144,228 (35%)	3,314 (18%)
60 and above	19,924 (5%)	246 (1%)
Total	413,022	18,843

Table 4.5. Hispanic Ethnicity and Gender Distribution in Florida Firefighters/Volunteers by Cancer Incidence and Overall Mortality

		Male (%)	Female (%)	Total*
Cancer Incidence Cases				
Professional firefighter	Hispanic	33 (89.2)	4 (10.8)	37 (3.6)
	Non-Hispanic	937 (95.1)	48 (4.9)	985 (96.4)
	Subtotal	970	52	1,022
Volunteer	Hispanic	24 (92.3)	2 (7.7)	26 (3.2)
	Non-Hispanic	656 (82.0)	144 (18.0)	800 (96.8)
	Subtotal	680	146	826
All Deaths				
Professional firefighter	Hispanic	53 (98.2)	1 (1.8)	54 (3.8)
	Non-Hispanic	1,326 (97.4)	36 (2.6)	1,362 (96.2)
	Subtotal	1,379	37	1,416
Volunteer	Hispanic	31 (88.6)	4 (11.4)	35 (2.7)
	Non-Hispanic	1,147 (92.4)	95 (7.6)	1,242 (97.3)
	Subtotal	1,178	99	1,277

* Total may not add up due to missing values for gender and/or Hispanic ethnicity.

Table 4.6. Number and Proportion of Deaths by Cause of Death in Male and Female Professional Firefighters and Volunteers: 1972–1999

	Male			Female		
Cause of Death	Professional Firefighter n (%)	Volunteer n (%)	Florida %	Professional Firefighter n (%)	Volunteer n (%)	Florida %
Malignant neoplasm	404 (28.6)	296 (27.0)	22.9	8 (21.5)	39 (41.1)	22.4
Non-cancer	946(67.1)	753(68.8)	72.5	30(78.5)	55(57.8)	72.2
Infectious	37 (2.6)	20 (1.8)	2.3	1 (2.6)	4 (4.2)	1.3
Circulatory	390 (27.6)	322 (29.4)	43.6	13 (34.2)	17 (17.9)	46.4
Respiratory	31 (2.2)	25 (2.3)	4.9	3 (7.9)	2 (2.1)	4.5
Digestive	55 (3.9)	22 (2.0)	3.2	1 (2.6)	4 (4.2)	3.2
External causes	269 (19.1)	190 (17.4)	7.7	9 (23.7)	13 (13.7)	3.8
Other causes	164 (11.6)	174 (15.9)	10.8	3 (7.9)	15 (15.8)	13
Unknown	61 (4.3)	46 (4.2)	4.6	0	1 (1.1)	5.4
Total	1411	1095		38	95	

Table 4.7. Standardized Incidence Ratio* (SIR) for Male Florida Professional Firefighters: 1981–1999

Site	Male Professional Firefighter		
	Observed Number	SIR	95% CI
All-Site Combined	970	**0.84**	**0.79-0.90**
Buccal	39	**0.67**	**0.47-0.91**
Digestive	156	**0.76**	**0.65-0.89**
Esophagus	11	0.62	0.31-1.11
Stomach	14	**0.50**	**0.25-0.90**
Colon	39	1.16	0.92-1.45
Rectum	23	0.88	0.56-1.32
Liver	8	0.74	0.32-1.46
Pancreas	12	0.57	0.30-1.10
Respiratory	154	**0.67**	**0.57-0.78**
Larynx	20	0.73	0.44-1.12
Lung and Bronchus	128	**0.65**	**0.54-0.78**
Bone	4	1.02	0.27-2.61
Skin	99	1.17	0.95-1.42
Bladder	73	**1.29**	**1.01-1.62**
Kidney	27	0.78	0.52-1.14
Eye	4	1.54	0.42-3.95
Brain/CNS	14	**0.58**	**0.31-0.97**
Thyroid	20	**1.77**	**1.08-2.73**
All Lymphopoietic	78	**0.68**	**0.54-0.85**
Non-Hodgkins	15	1.09	0.61-1.80
Hodgkins	11	0.77	0.38-1.38
Leukemia	20	0.77	0.47-1.19
Prostate	209	1.10	0.95-1.42
Testes	54	**1.60**	**1.20-2.09**
Soft Tissue Sarcoma	14	1.00	0.55-1.69

* The SIRs were adjusted for age, sex, and calendar year using cancer incidence data from 1981–1999 for Florida men as the comparison population; significant findings are in bold.

Table 4.8. Standardized Incidence Ratio* (SIR) for Hispanic Male Florida Professional Firefighters: 1981–1999

Site	Hispanic Male Professional Firefighter		
	Observed Number	SIR	95% CI
All-Site Combined	33	0.72	0.50-1.02
Buccal	0		
Digestive	8	1.09	0.47-2.14
Esophagus	0		
Stomach	0		
Colon	4	1.79	0.48-4.59
Rectum	1	1.20	0.02-6.70
Liver	0		
Pancreas	2	3.39	0.38-12.2
Respiratory	4	0.50	0.13-1.28
Larynx	0		
Lung and Bronchus	4	0.59	0.16-1.51
Bone	0		
Skin	2	0.48	0.05-1.72
Bladder	2	1.03	0.12-3.70
Kidney	0		
Eye	0		
Brain/CNS	1	1.00	0.01-5.56
Thyroid	4	**11.1**	**2.99-28.5**
All Lymphopoietic	6	1.11	0.41-2.42
Non-Hodgkins	0		
Hodgkins	2	2.63	0.30-9.50
Leukemia	1	1.00	0.01-5.56
Prostate	5	0.83	0.27-1.94
Testes	0		
Soft Tissue Sarcoma	0		

* The SIRs were adjusted for age, sex, and calendar year using cancer incidence data from 1981–1999 for Florida Hispanic men as the comparison population; significant findings are in bold.

Table 4.9. Standardized Incidence Ratio* (SIR) for Non-Hispanic Male Florida Professional Firefighters: 1981–1999

Site	Non-Hispanic Male Professional Firefighter		
	Observed Number	SIR	95% CI
All-Site Combined	937	**0.82**	**0.76-0.87**
Buccal	39	**0.66**	**0.47-0.90**
Digestive	148	**0.73**	**0.62-0.86**
Esophagus	11	0.60	0.30-1.07
Stomach	11	**0.52**	**0.26-0.93**
Colon	74	1.13	0.88-1.41
Rectum	22	0.84	0.53-1.27
Liver	8	0.79	0.34-1.55
Pancreas	10	0.47	0.23-0.87
Respiratory	150	**0.64**	**0.54-0.75**
Larynx	20	0.74	0.45-1.16
Lung and Bronchus	124	**0.62**	**0.52-0.74**
Bone	4	1.07	0.29-2.74
Skin	97	1.15	0.94-1.41
Bladder	71	1.24	0.97-1.57
Kidney	7	0.60	0.24-1.23
Eye	4	1.54	0.42-3.95
Brain/CNS	13	0.55	0.29-0.94
Thyroid	16	1.46	0.83-2.36
All Lymphopoietic	72	**0.65**	**0.51-0.82**
Non-Hodgkins	15	1.11	0.62-1.82
Hodgkins	9	0.67	0.30-1.27
Leukemia	19	0.74	0.45-1.16
Prostate	204	1.08	0.94-1.24
Testes	54	**1.57**	**1.18-2.05**
Soft Tissue Sarcoma	14	1.09	0.59-1.83

* The SIRs were adjusted for age, sex, and calendar year using cancer incidence data from 1981–1999 for Non-Hispanic Florida men as the comparison population; significant findings are in bold.

Table 4.10. Standardized Incidence Ratio* (SIR) for the Early Cohort of Male Florida Professional Firefighters Certified between 1972 and 1976

Site	Male Professional Firefighter		
	Observed Number	SIR	95% CI
All-Site Combined	686	0.99	0.92-1.07
Buccal	29	0.79	0.53-1.14
Digestive	126	0.96	0.80-1.14
Esophagus	8	0.68	0.29-1.33
Stomach	8	0.58	0.25-1.14
Colon	65	**1.47**	**1.13-1.87**
Rectum	18	1.09	0.64-1.72
Liver	7	1.17	0.47-2.42
Pancreas	10	0.73	0.64-2.30
Respiratory	128	0.81	0.67-0.96
Larynx	18	0.94	0.55-1.48
Lung and Bronchus	105	0.77	0.63-0.94
Bone	1	0.75	0.01-4.15
Skin	58	**1.61**	**1.22-2.08**
Bladder	56	**1.49**	**1.13-1.94**
Kidney	20	0.92	0.56-1.43
Eye	0		
Brain/CNS	7	0.60	0.24-1.24
Thyroid	6	1.21	0.44-2.64
All Lymphopoietic	48	0.88	0.65-1.17
Non-Hodgkins	11	1.29	0.64-2.30
Hodgkins	6	1.39	0.51-3.02
Leukemia	10	0.73	0.35-1.35
Prostate	176	**1.35**	**1.15-1.56**
Testes	7	0.94	0.38-1.94
Soft Tissue Sarcoma	8	1.37	0.59-2.71

* The SIRs were adjusted for age, sex, and calendar year using cancer incidence data from 1981–1999 for Florida men as the comparison population; significant findings are in bold.

Table 4.11. Standardized Incidence Ratio* (SIR) for Female Florida Professional Firefighters: 1981–1999

Site	Female Professional Firefighter		
	Observed Number	SIR	95% CI
All-Site Combined	52	**1.63**	**1.22-2.14**
Buccal	0		
Digestive	3	1.02	0.21-2.98
Esophagus	0		
Stomach	0		
Colon	2	2.27	0.26-8.21
Rectum	1	5.26	0.07-29.3
Liver	0		
Pancreas	0		
Respiratory	3	1.40	0.28-4.08
Larynx	0		
Lung and Bronchus	3	1.51	0.30-4.40
Bone	0		
Skin	5	3.01	0.97-7.03
Bladder	1	10.00	0.13-55.6
Kidney	3	**6.25**	**1.26-18.3**
Eye	0		
Brain/CNS	0		
Thyroid	6	**3.97**	**1.45-8.65**
All Lymphopoietic	6	2.62	0.96-5.7
Non-Hodgkins	1	33.3	0.44-185
Hodgkins	0		
Leukemia	0		
Breast	0		
Cervix	0		
Soft Tissue Sarcoma	0		

* The SIRs were adjusted for age, sex, and calendar year using cancer incidence data from 1981–1999 for Florida women as the comparison population; significant findings are in bold.

Table 4.12. Standardized Mortality Ratio* (SMR) for Cancer Deaths in Male Florida Professional Firefighters: 1972–1999

Cause of death (Cancer site)	Male Professional Firefighter		
	Observed Number	SMR	95% CI
All-Site Combined	403	**0.85**	**0.77-0.94**
Buccal/Pharynx	7	**0.42**	**0.17-0.87**
Digestive	93	0.86	0.70-1.06
Esophagus	10	0.65	0.31-1.20
Stomach	12	0.86	0.52-1.42
Colon	38	1.14	0.81-1.56
Rectum	7	0.94	0.38-1.93
Liver	10	0.85	0.41-1.56
Pancreas	12	**0.57**	**0.29-0.99**
Respiratory	155	0.88	0.75-1.03
Larynx	0		
Lung and Bronchus	155	0.93	0.79-1.09
Bone	1	0.52	0.01-2.91
Skin	17	0.89	0.52-1.42
Bladder/Kidney	21	1.07	0.66-1.64
Bladder	14	1.79	0.98-3.00
Eye	0		
Brain/CNS	13	0.66	0.35-1.13
Thyroid	4	**4.82**	**1.30-12.3**
All Lymphopoietic	42	0.77	0.56-1.05
Lymphosarcoma	3	0.65	0.13-1.90
Hodgkins	1	0.23	0.00-1.30
Leukemia	14	0.84	0.46-1.42
Prostate	21	1.08	0.67-1.65
Male Breast	4	**7.41**	**1.99-19.0**

* The SMRs were adjusted for age, sex, and calendar year using mortality data between 1972 and 1999 for Florida men ages 20 to 100 as the reference population; significant findings are in bold.

Table 4.13. Standardized Mortality Ratio* (SMR) for Cancer Deaths in the Subcohort of Male Florida Professional Firefighters Certified between 1972 and 1976

	Male Professional Firefighter		
Cause of death (Cancer site)	Observed Number	SMR	95% CI
All-Site Combined	330	0.89	0.80-1.00
Buccal/Pharynx	5	**0.38**	**0.12-0.89**
Digestive	78	0.91	0.72-1.44
Esophagus	7	0.55	0.22-1.14
Stomach	10	0.92	0.68-2.00
Colon	33	1.22	0.84-1.72
Rectum	6	1.04	0.38-2.26
Liver	7	0.83	0.33-1.71
Pancreas	12	0.70	0.36-1.22
Respiratory	134	0.90	0.76-1.07
Larynx	0		
Lung and Bronchus	134	0.96	0.80-1.13
Bone	1	1.06	0.01-5.92
Skin	15	1.21	0.68-2.00
Bladder/Kidney	17	1.07	0.62-1.71
Bladder	13	**1.95**	**1.04-3.33**
Eye	0		
Brain/CNS	8	0.62	0.27-1.23
Thyroid	3	4.76	0.96-13.9
All Lymphopoietic	27	0.76	0.50-1.10
Lymphosarcoma	3	0.94	0.19-2.76
Hodgkins	0		
Leukemia	8	0.74	0.3-1.45
Prostate	19	1.07	0.65-1.68
Breast	3	6.98	1.40-20.4

* The SMRs were adjusted for age, sex, and calendar year using mortality data between 1972 and1976 for Florida men ages 20 to 100 as the reference population; significant findings are in bold.

Table 4.14. Standardized Mortality Ratio* (SMR) for Cancer Deaths in Female Florida Professional Firefighters: 1972–1999

Cause of death (Cancer site)	Female Professional Firefighter		
	Observed Number	SMR	95% CI
All-Site Combined	8	1.03	0.44-2.03
Buccal/Pharynx	0		
Digestive	1	0.88	0.01-4.92
Esophagus	0		
Stomach	0		
Colon	1	2.27	0.03-12.7
Rectum	0		
Liver	0		
Pancreas	0		
Respiratory	3	2.16	0.43-6.31
Larynx	0		
Lung and Bronchus	3	2.22	0.45-6.49
Bone	0		
Skin	0		
Bladder/Kidney	0		
Bladder	0		
Eye	0		
Brain/CNS	0		
Thyroid	0		
All Lymphopoietic	1	1.25	0.02-6.95
Lymphosarcoma	0		
Hodgkins	0		
Leukemia	0		
Breast	1	0.51	0.01-2.82

* The SMRs were adjusted for age, sex, and calendar year using mortality data between 1972 and1999 for Florida women ages 20 to 100 as the reference population.

Table 4.15. Standardized Mortality Ratio* (SMR) for Non-Cancer Deaths in Male Florida Professional Firefighters: 1972–1999

Cause of death (Non-cancer)	Male Professional Firefighter		
	Observed Number	SMR	95% CI
All Known Causes	1349	**0.57**	**0.54-0.60**
Infectious Diseases	38	**0.16**	**0.11-0.22**
Tuberculosis	5	1.10	0.35-2.56
Allergic/Endocrine	22	**0.35**	**0.22-0.52**
Diabetes	16	**0.45**	**0.26-0.73**
Diseases of Blood	6	0.73	0.27-1.59
Mental	14	**0.41**	**0.22-0.68**
Nervous System	17	**0.54**	**0.31-0.86**
Circulatory System	424	**0.69**	**0.63-0.76**
ASHD (w/CHD)	263	**0.73**	**0.65-0.83**
CNS Vascular	54	0.80	0.60-1.05
Respiratory Diseases	35	**0.50**	**0.35-0.70**
Pneumonia	11	**0.34**	**0.17-0.62**
Emphysema	9	0.87	0.40-1.66
Asthma	0		
Digestive Diseases	60	**0.57**	**0.43-0.73**
Cirrhosis	33	**0.49**	**0.34-0.69**
Genitourinary	6	**0.38**	**0.14-0.83**
External Causes	285	**0.45**	**0.40-0.50**
Accidents	162	**0.48**	**0.41-0.56**
Motor Vehicle	90	**0.45**	**0.36-0.55**
Suicide	83	**0.55**	**0.44-0.68**

* The SMRs were adjusted for age, sex, and calendar year using mortality data between 1972 and 1999 for Florida men ages 20 to 100 as the reference population; significant findings are in bold.

Table 4.16. Standardized Mortality Ratio* (SMR) for Non-Cancer Deaths in a Subcohort of Male Florida Professional Firefighters Certified between 1972 and 1976

Cause of death (Non-cancer)	Male Professional Firefighter		
	Observed Number	SMR	95% CI
All Known Causes	1003	**0.68**	**0.64-0.73**
Infectious Diseases	18	**0.24**	**0.14-0.37**
Tuberculosis	5	1.60	0.51-3.73
Allergic/Endocrine	16	**0.39**	**0.22-0.63**
Diabetes	11	**0.43**	**0.21-0.76**
Diseases of Blood	6	1.33	0.48-2.89
Mental	12	**0.56**	**0.29-0.98**
Nervous System	14	0.71	0.39-1.2
Circulatory System	354	**0.73**	**0.66-0.81**
ASHD (w/CHD)	222	**0.76**	**0.66-0.86**
CNS Vascular	47	0.91	0.67-1.22
Respiratory Diseases	31	**0.60**	**0.41-0.86**
Pneumonia	9	**0.41**	**0.19-0.78**
Emphysema	8	0.88	0.38-1.74
Asthma	0		
Digestive Diseases	53	**0.71**	**0.53-0.93**
Cirrhosis	29	**0.60**	**0.40-0.86**
Genitourinary	6	0.52	0.19-1.13
External Causes	133	**0.51**	**0.43-0.61**
Accidents	73	**0.53**	**0.41-0.66**
Motor Vehicle	38	**0.50**	**0.35-0.68**
Suicide	42	**0.64**	**0.46-0.87**

* The SMRs were adjusted for age, sex, and calendar year using mortality data between 1972 and 1999 for Florida men ages 20 to 100 as the reference population; significant findings are in bold.

Table 4.17. Standardized Mortality Ratio* (SMR) for Non-Cancer Deaths in Female Florida Professional Firefighters: 1972–1999

Cause of death (Non-cancer)	Female Professional Firefighter		
	Observed Number	SMR	95% CI
All Known Causes	38	1.24	0.87-1.70
Infectious Diseases	1	0.27	0.00-1.52
Tuberculosis	0		
Allergic/Endocrine	0		
Diabetes	0		
Diseases of Blood	0		
Mental	0		
Nervous System	0		
Circulatory System	13	**2.49**	**1.32-4.25**
ASHD (w/CHD)	8	**3.85**	**1.66-7.58**
CNS Vascular	0		
Respiratory Diseases	3	2.88	0.58-8.43
Pneumonia	2	4.35	0.49-15.7
Emphysema	1	12.5	0.16-69.6
Asthma	0		
Digestive Diseases	2	1.60	0.18-5.78
Cirrhosis	1	1.43	0.02-7.95
Genitourinary	0		
External Causes	9	1.20	0.55-2.28
Accidents	4	0.95	0.26-2.43
Motor Vehicle	2	0.68	0.08-2.45
Suicide	4	2.52	0.68-6.44

* The SMRs were adjusted for age, sex, and calendar year using mortality data between 1972 and1999 for Florida women ages 20 to 100 as the reference population; significant findings are in bold.

Table 4.18. Proportional Mortality Ratio* (PMR) for Cancer Deaths in Male Florida Professional Firefighters: 1972–1999

Cause of death (Cancer site)	Male Professional Firefighter		
	Observed Number	PMR	95% CI
All-Site Combined	404	**1.19**	**1.07-1.30**
Buccal/Pharynx	7	0.66	0.17-1.15
Digestive	93	**1.25**	**1.00-1.51**
Esophagus	10	1.14	0.44-1.85
Stomach	12	1.20	0.52-1.87
Colon	38	**1.54**	**1.05-2.03**
Rectum	7	1.33	0.34-2.31
Liver	10	1.57	0.60-2.55
Pancreas	12	0.81	0.35-1.26
Respiratory	155	**1.25**	**1.05-1.44**
Larynx	0		
Lung	155	**1.31**	**1.10-1.52**
Bone	1	0.99	0.00-2.94
Skin	17	1.69	0.89-2.49
Bladder/Kidney	21	1.48	0.85-2.11
Bladder	14	**2.11**	**1.01-3.22**
Kidney	7	0.93	0.24-1.61
Eye	0		
Brain/CNS	13	1.19	0.54-1.84
Thyroid	4	8.05	0.16-16.0
All Lymphopoietic	42	1.35	0.94-1.76
Lymphosarcoma	3	0.97	0.00-2.07
Hodgkins	1	0.10	**0.00-0.30**
Leukemia	14	1.43	0.68-2.18
Other Lymphatic	22	1.38	0.80-1.95
Soft Tissue Sarcoma	3	1.45	0.00-3.10
Prostate	21	1.17	0.67-1.67
Breast	4	**186**	**3.72-368**

* The PMRs were adjusted for age; mortality data between 1972-1999 for Florida men ages 20 to 100 were used as the reference population; significant findings are in bold.

Table 4.19. Proportional Mortality Ratio* (PMR) for Cancer Deaths in Male Florida Volunteers: 1972–1999

Cause of death (Cancer site)	Male Volunteer		
	Observed Number	PMR	95% CI
All-Site Combined	296	1.12	0.99-1.25
Buccal/Pharynx	4	0.57	0.01-1.14
Digestive	68	1.21	0.93-1.50
Esophagus	10	1.48	0.56-2.39
Stomach	5	0.66	0.08-1.25
Colon	19	0.98	0.54-1.41
Rectum	7	1.79	0.46-3.12
Liver	9	1.94	0.67-3.20
Pancreas	13	1.17	0.53-1.81
Respiratory	109	**1.23**	**1.00-1.46**
Larynx	0		
Lung	109	**1.29**	**1.05-1.53**
Bone	0		
Skin	13	1.84	0.84-2.84
Bladder/Kidney	13	1.15	0.53-1.78
Bladder	5	0.85	0.11-1.60
Kidney	8	1.47	0.45-2.49
Eye	0		
Brain/CNS	8	1.06	0.33-1.80
Thyroid	4	8.05	0.16-15.9
All Lymphopoietic	30	1.26	0.81-1.71
Lymphosarcoma	1	0.44	0.00-1.30
Hodgkins	1	**0.13**	**0.00-0.39**
Leukemia	5	0.65	0.08-1.23
Other Lymphatic	24	**1.96**	**1.18-2.75**
Soft Tissue Sarcoma	4	2.64	0.05-5.23
Prostate	20	1.09	0.61-1.57
Breast	1	62.3	0.00-185

* The PMRs were adjusted for age; mortality data between 1972 and 1999 for Florida men ages 20 to 100 were used as the reference population; significant findings are in bold.

Table 4.20. Proportional Mortality Ratio* (PMR) for Cancer Deaths in Male Florida Professional Firefighters Using the Volunteers as the Comparison: 1972–1999

Cause of death (Cancer site)	Male Professional Firefighter		
	Observed Number	PMR	95% CI
All-Site Combined	*404*	*1.06*	*0.96-1.16*
Buccal/Pharynx	7	1.23	0.32-2.14
Digestive	93	0.99	0.79-1.19
Esophagus	10	0.78	0.30-1.26
Stomach	12	1.70	0.74-2.66
Colon	38	**1.52**	**1.04-2.01**
Rectum	7	**0.56**	**0.15-0.98**
Liver	10	0.92	0.35-1.50
Pancreas	12	0.67	0.29-1.05
Respiratory	155	1.00	0.84-1.15
Larynx	0		
Lung	155	1.00	0.84-1.55
Bone	1		
Skin	17	0.87	0.45-1.28
Bladder/Kidney	21	1.15	0.66-1.64
Bladder	14	1.79	0.85-2.73
Kidney	7	0.67	0.17-1.16
Eye	0		
Brain/CNS	13	1.14	0.52-1.76
Thyroid	4	1.00	0.02-1.98
All Lymphopoietic	42	1.06	0.74-1.39
Lymphosarcoma	3	5.63	0.00-12.0
Hodgkins	1	0.85	0.00-2.53
Leukemia	14	1.84	0.87-2.80
Other Lymphatic	22	0.70	0.41-1.00
Soft Tissue Sarcoma	3	0.60	0.00-1.28
Prostate	21	0.93	0.53-1.32
Breast	4	4.39	0.09-8.70

* The PMRs were adjusted for age using the mortality data of the male volunteer firefighters as the comparison population; significant findings are in bold.

Table 4.21. Proportional Mortality Ratio* (PMR) for Non-Cancer Deaths in Male Florida Professional Firefighters (N = 35,777): 1972–1999

	Male Professional Firefighter		
Cause of Non-Cancer Death	Observed Number (Total death = 1,411)	PMR	95% CI
Infectious Diseases	37	1.15	0.78-1.52
Tuberculosis	5	1.66	0.20-3.11
Allergic/Endocrine	19	**0.59**	**0.33-0.86**
Diabetes	16	0.74	0.38-1.10
Diseases of Blood	6	1.44	0.29-2.58
Mental	12	0.70	0.31-1.12
Nervous System	16	0.97	0.50-1.45
Circulatory System	390	**0.85**	**0.76-0.93**
ASHD (w/CHD)	246	**0.84**	**0.73-0.94**
AHD	281	**0.87**	**0.77-0.97**
CNS Vascular	47	0.91	0.65-1.17
Respiratory Diseases	31	**0.18**	**0.12-0.24**
Pneumonia	11	**0.53**	**0.22-0.84**
Emphysema	8	**0.47**	**0.14-0.79**
Asthma	0		
Digestive Diseases	55	**0.40**	**0.30-0.51**
Cirrhosis	32	0.80	0.52-1.07
Genitourinary	6	**0.54**	**0.11-0.97**
External Causes	269	1.04	0.92-1.17
Accidents	156	1.13	0.95-1.30
Motor Vehicle	88	1.10	0.87-1.33
Suicide	78	1.25	0.97-1.53

* The PMRs were adjusted for age; mortality data between 1972 and 1999 for Florida men ages 20 to 100 were used as the reference population; significant findings are in bold.

Table 4.22. Proportional Mortality Ratio* (PMR) for Non-Cancer Deaths in Male Florida Volunteers (N = 29,218): 1972–1999

	Male Volunteer		
Cause of Non-Cancer Death	Observed Number (Total death = 1,095)	PMR	95% CI
Infectious Diseases	20	0.80	0.45-1.15
Tuberculosis	0		
Allergic/Endocrine	23	0.94	0.55-1.32
Diabetes	18	1.08	0.58-1.58
Diseases of Blood	4	1.16	0.02-2.30
Mental	11	0.90	0.37-1.44
Nervous System	17	1.23	0.65-1.82
Circulatory System	322	**0.86**	**0.77-0.96**
ASHD (w/CHD)	199	**0.85**	**0.73-0.97**
AHD	232	0.90	0.78-1.01
CNS Vascular	24	**0.53**	**0.32-0.74**
Respiratory Diseases	25	**0.19**	**0.12-0.27**
Pneumonia	11	**0.61**	**0.25-0.98**
Emphysema	3	**0.24**	**0.00-0.52**
Asthma	0		
Digestive Diseases	22	**0.22**	**0.13-0.32**
Cirrhosis	14	**0.55**	**0.26-0.84**
Genitourinary	3	**0.30**	**0.00-0.63**
External Causes	190	0.94	0.81-1.08
Accidents	119	1.07	0.88-1.26
Motor Vehicle	83	**1.27**	**1.00-1.54**
Suicide	53	1.13	0.83-1.44

* The PMRs were adjusted for age; mortality data between 1972 and 1999 for Florida men ages 20 to 100 were used as the reference population; significant findings are in bold.

Table 4.23. Proportional Mortality Ratio* (PMR) for Non-Cancer Deaths in Female Florida Professional Firefighters (N = 2,165): 1972–1999

	Female Professional Firefighter		
Cause of Non-Cancer Death	Observed Number (Total death = 38)	PMR	95% CI
Infectious Diseases	1	2.05	0.00-6.08
Tuberculosis	0		
Allergic/Endocrine	0		
Diabetes	0		
Diseases of Blood	0		
Mental	0		
Nervous System	0		
Circulatory System	13	**0.32**	**0.15-0.50**
ASHD (w/CHD)	8	0.68	0.21-1.15
AHD	8	1.70	0.52-2.87
CNS Vascular	0		
Respiratory Diseases	3	0.81	0.00-1.72
Pneumonia	2	3.62	0.00-8.64
Emphysema	1	5.01	0.00-14.82
Asthma	0		
Digestive Diseases	1	**0.27**	**0.00-0.87**
Cirrhosis	1	0.99	0.00-2.93
Genitourinary	0		
External Causes	9	1.00	0.35-1.65
Accidents	4	1.12	0.02-2.21
Motor Vehicle	2	0.81	0.00-1.93
Suicide	4	2.46	0.05-4.86

* The PMRs were adjusted for age; mortality data between 1972 and1999 for Florida women ages 20 to 100 were used as the reference population; significant findings are in bold.

Table 4.24. Proportional Mortality Ratio* (PMR) for Non-Cancer Deaths in Female Florida Volunteers (5,628): 1972–1999

	Female Volunteer		
Cause of Non-Cancer Death	Observed Number (Total death = 95)	PMR	95% CI
Infectious Diseases	4	3.29	0.07-6.51
Tuberculosis	0		
Allergic/Endocrine	0		
Diabetes	0		
Diseases of Blood	1	1.93	0.00-5.72
Mental	0		
Nervous System	0		
Circulatory System	17	**0.16**	**0.09-0.24**
ASHD (w/CHD)	8	**0.30**	**0.09-0.51**
AHD	9	0.76	0.26-1.26
CNS Vascular	3	0.59	0.00-1.59
Respiratory Diseases	2	**0.23**	**0.00-0.55**
Pneumonia	1	0.68	0.00-2.00
Emphysema	1	5.01	0.00-14.8
Asthma	1	2.41	0.00-7.14
Digestive Diseases	4	**0.45**	**0.01-0.88**
Cirrhosis	3	1.12	0.00-2.39
Genitourinary	1	0.38	0.00-1.12
External Causes	13	0.79	0.36-1.22
Accidents	10	1.13	0.43-1.83
Motor Vehicle	7	1.15	0.30-2.00
Suicide	0		

* The PMRs were adjusted for age; mortality data between 1972 and 1999 for Florida women ages 20 to 100 were used as the reference population; significant findings are in bold.

FIGURES

Figure 3.1. Data Linkage Flowchart in a Retrospective Cohort Study of Florida Firefighters

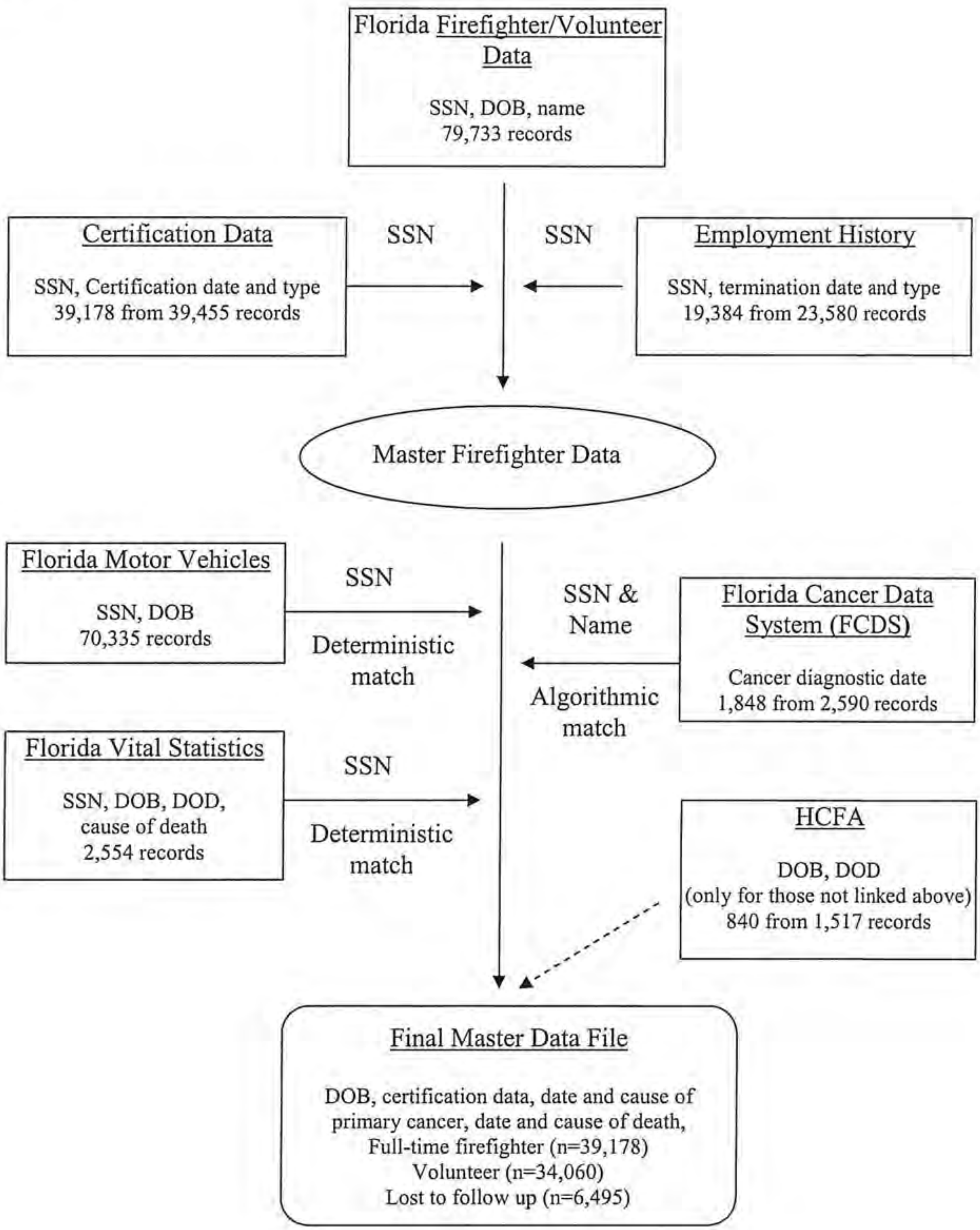
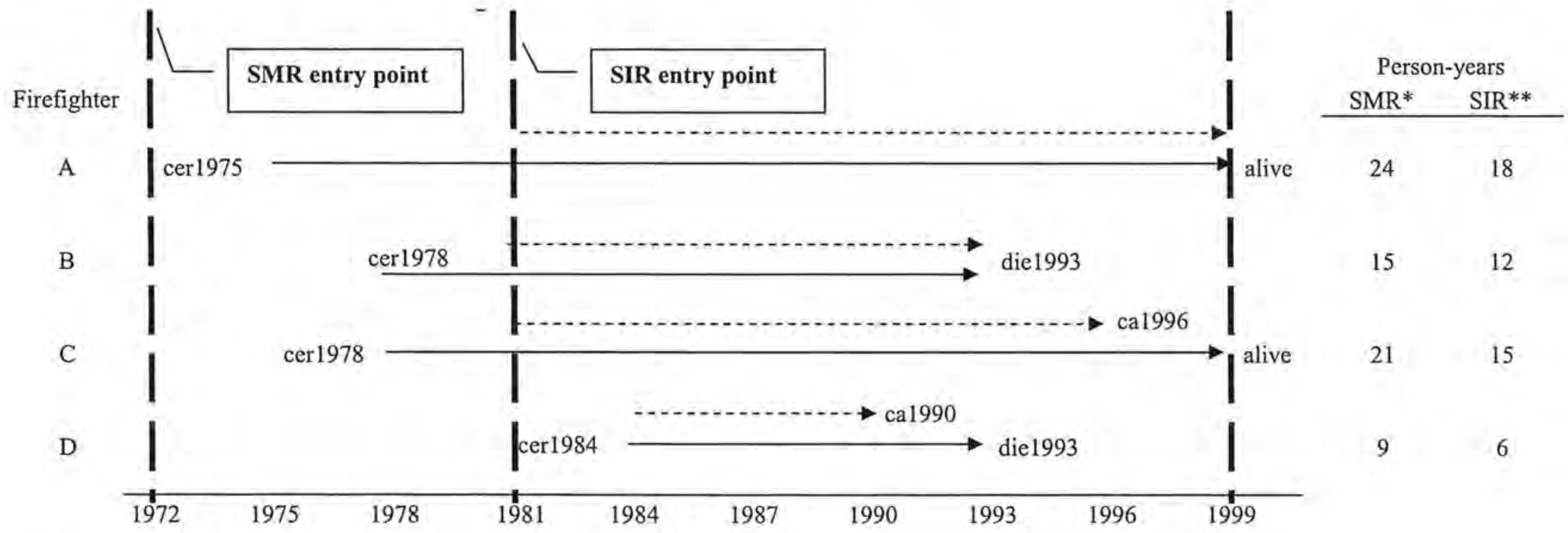


Figure 3.2. Scheme for Person-year Calculations in SMR and SIR Studies



Legend: cer1975, i.e., certified in 1975.
alive, i.e., found in the firefighter data linkage with Motor Vehicles or FCFA, not found in linkages with Death Tapes or FCDS.
die1993, i.e., died in 1993.
ca1996, i.e., cancer diagnosed in 1996.

*Person-year calculation for SMR:
Entry point: the certification date;
Exit point: the last year known to be alive in Florida (based on linkage with the Dept of Motor Vehicles or FCFA), the date of death (based on linkage with the Vital Statistics, FCDS or HCFA), or the end of the study period, whichever came first.

**Person-year calculation for SIR:
Entry point: 01/01/1981 if certified before 1981 or the certification date if certified after;
Exit point: the last year known to be alive in Florida, the date of incident cancer diagnosis (FCDS), the date of death (based on linkage with the Vital Statistics, FCDS and HCFA), or the end of the study period, whichever came first.

APPENDICES

University of Miami IRB Approval of the Study Protocol

Letters of Support

1. Florida Professional Firefighters Health and Safety Committee
2. The Treasurer of the State of Florida Department of Insurance
3. Florida Department of Health, Chronic Disease Epidemiology
4. Florida Cancer Data System
5. State of Florida Department of Highway Safety and Motor Vehicles
6. Florida Department of Health, State Office of Vital Statistics

UNIVERSITY OF Miami

SCHOOL OF MEDICINE

MEMORANDUM

TO: David J. Lee, Ph.D.
Department of Epidemiology & Public Health

FROM: Patricia Thomas, MPA, IRB Administrator PT/vv
Medical Sciences Committee "B"

DATE: May 15, 2002

PROTOCOL NUMBER: **95/121B**

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

ANNUAL APPROVAL DATE: April 29, 2002

DATE OF EXPIRATION: April 28, 2003

Thank you for your recent submission of the above-titled continuing report with waiver of consent form.

The Institutional Review Board (IRB) has approved this continuing report according to the 45 CFR 46 Protection of Human Subjects Policy. This expedited review is in accordance with 45 CFR 46.110(8). *Continuing review of research previously approved by the convened IRB as follows:* ***(a)*** *where (i) the research is permanently closed to the enrollment of new subjects; (ii) all subjects have completed all research-related interventions; and (iii) the research remains active only for long-term follow-up of subjects; or* ***(b)*** *where no subjects have been enrolled and no additional risks have been identified; or* ***(c)*** *where the remaining research activities are limited to data analysis.*

Any and all changes to the protocol must be submitted to the IRB for review before its implementation.

If you have any questions, please feel free to contact Vernice Vixamar at (305) 243-6713.

Human Subjects Office (M-809)
P.O. Box 016960 Tel: 305-243-3195
Miami, Florida 33101
Fax: 305-243-3328

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October 26, 1998

Dr. Lora Fleming, MD
Associate Professor
Department of Epidemiology &
Public Health
University of Miami School of Medicine
P.O. Box 016069
Miami, FL 33101

Florida Professional Firefighters
Health & Safety Committee

Dear Dr. Fleming,

The 13,500 members of the Florida Professional Firefighters wish to express our enthusiasm and support for your proposed study " Florida Firefighter Cancer Incidence and Overall Mortality".

As Chairman for the F.P.F. standing committee on Health & Safety I have been concerned for many years that Firefighters succumb to cancer at rates that are higher than those found in most other occupational groups.

As always our organization will do everything in our power to see that your study progresses smoothly.

Sincerely,

Jim Brantley

Chairman
Florida Professional Firefighters
Health & Safety Committee

Cc: Florida Professional Firefighters
Dr. David Lee

THE TREASURER OF THE STATE OF FLORIDA
DEPARTMENT OF INSURANCE

BILL NELSON

October 7, 1998

Lora Fleming, MD
Associate Professor
Department of Epidemiology & Public Health
University of Miami School of Medicine
P. O. Box 016069 (R-669)
Miami, FL 33101

Dear Dr. Fleming:

We are writing this letter to confirm our support of your proposal study, "Florida Firefighter Cancer Incidence and Overall Mortality."

As you know, we have already submitted to you in electronic format the certification records of over 32,000 Florida Firefighters. We are in the process of entering into our computer an additional 10,000 records that were obtained before our office employed a computerized record keeping system. We expect to have all of these records entered, at the latest, by June of next year. When completed we will provide you with another electronic file with these records.

If any further information is needed, please let us know.

Sincerely,

Mary Poteat

Mary Poteat
Staff Assistant-Coordinator

TREASURER • INSURANCE COMMISSIONER • FIRE MARSHAL

• • •

MARY POTEAT • STAFF ASSISTANT-COORDINATOR • BUREAU OF FIRE STANDARDS AND TRAINING
11655 NW GAINESVILLE ROAD • OCALA, FLORIDA 34482-1486 • (352) 732-1330 • TELECOPIER (352)732-1374

FLORIDA DEPARTMENT OF HEALTH

Lawton Chiles
Governor

James T. Howell, M.D., M.P.H.
Secretary

October 22, 1998

Lora E.Fleming, M.D., Ph.D., M.P.H.
Associate Professor
University of Miami School of Medicine
Dept. of Epidemiology & Public Health
P.O. Box 016069 (R-669)
Miami, FL. 33101

Dear Dr. Fleming:

Your request to access confidential identifying data from the Florida Statewide Cancer Registry was reviewed by the Review Council for Human Subjects (RCHS) and it was determined that their approval is not required. It has also been reviewed by a review committee appointed by the State Epidemiologist and any comments from the committee have been enclosed for your review.

The request relating to "General Mortality and Cancer Incidence in a Cohort of Florida Professional Fire Fighters" is approved. By copy of this letter, I am requesting that Jill MacKinnon, FCDS Administrative Director, assist you in accessing data for this application. You may contact Ms. MacKinnon at:

Florida Cancer Data System
University of Miami School of Medicine
1550 N.W. 10th Avenue
Miami, Florida 33136
Telephone: (305)243-4600

If you need any further assistance, please call me at 850/922-5089. **We look forward to receiving a copy of the results of your work.**

Sincerely,

Stephen R. Schmidt
Operations & Management Consultant
DOH, Chronic Disease Epidemiology

cc: Dr. Hopkins
Dan Thompson
Jill MacKinnon

CONFIDEN\1998\LTR-RSP.DOC

FCDS Florida Cancer Data System
A Joint Project of the Sylvester Comprehensive Cancer Center and the Florida Department of Health
FLORIDA DEPARTMENT OF HEALTH
Edward J. Trapido, Sc.D., Project Director
Jill A. MacKinnon, CTR, Administrative Director
305-243-4600 (Voice)
305-243-4871 (Fax)

October 28, 1998

Dr. Lora E. Fleming, M.D., Ph.D., M.P.H.
Associate Professor
University of Miami School of Medicine
Department of Epidemiology and Public Health
P.O. Box 016960 (R-669)
Miami, Florida 33101

RE: General Mortality and Cancer Incidence in a Cohort of Florida Professional Fire Fighters

Dear Dr. Flemming:

Your request for access to cancer data from the Florida Cancer Data System for the above referenced study was approved. FCDS staff will perform the linkage of the two data set, passing on the actual cost of the linkage to you.

We support this investigation and will do everything necessary to assist you with this study. As always, I look forward to working with you and your staff.

Please call me with any questions.

Sincerely,

Jill A. MacKinnon
Administrative Director

UNIVERSITY OF Miami SCHOOL OF MEDICINE
Post Office Box 016960 (D4-11) • Miami, Florida 33101 • 1-800-906-3034 • http://www.fcds.med.miami.edu

Fax:19044883824 Oct 28 '98 14:26 P.01

State of Florida
DEPARTMENT OF
HIGHWAY SAFETY AND MOTOR VEHICLES
TALLAHASSEE, FLORIDA 32399-0500

FRED O. DICKINSON, III
Executive Director

October 28, 1998

University of Miami School of Medicine
Post Office Box 016069
Miami, Florida 33101

Attention: Lora E. Fleming MD, PhD

Dear Doctor Fleming:

In reference to your correspondence dated October 12, 1998 and our telephone conversations, I have searched our records and found the following. We have a program in place for submitting social security numbers and retrieving a person's name and current address. This information can be obtained at the cost of one cent per record found. However, this program will not determine whether a person is deceased or not. Also, if the person's social security number has not been keyed into our database files, that person's record will not be found.

The only way to determine if a person is deceased is to submit the full name, date of birth and social security number and request a search be made on the individual. The deceased information would be in the driver history section of the report, if available, and may be purchased at a cost of $2.10 per record searched for.

Sincerely,

Sarah Chester
Bureau of Records
Division of Driver Licenses

SAC

DIVISIONS/FLORIDA HIGHWAY PATROL • DRIVER LICENSES • MOTOR VEHICLES • ADMINISTRATIVE SERVICES
Neil Kirkman Building, Tallahassee, Florida 32399-0500
http://www.state.fl.us/hsmv/index.html

FLORIDA DEPARTMENT OF HEALTH

Lawton Chiles
Governor

James T. Howell, M.D., M.P.H.
Secretary

October 12, 1998

Dr. Lora E. Fleming
c/o Department of Epidemiology and
Public Health
University of Miami School of Medicine
P. O. Box 016069 (R-669)
Miami, Florida 33101

Dear Dr. Fleming:

This is in response to your request for copies of death records including the cause of death. In Florida, death certificates including the cause of death section are confidential records by virtue of statutory provisions Chapter 382.008(6), Florida Statutes. The cause of death section of deaths are exempt from the above provisions for health research purposes approved by the department. It is the policy of the department to issue vital records data of this nature only for health research purposes.

If you wish to apply for approval of a research study, it will be necessary for you to complete the enclosed Data Purchase and Use Agreement Form and return it to our office with two copies of your research protocol, and the applicable fee. This request will not be processed without the applicable fees. The protocol should include, at a minimum, the purpose of the study, if there is to be any follow-back and to whom, and a destruction schedule for the records.

If the research study has prior approval through the National Death Index (NDI), please also provide us with the NDI application number or a copy of the first page of the application form.

We have also enclosed our current fee schedule, for your convenience.

If you have any questions, please call (904) 359-6960.

Sincerely,

Gary J. Sammet
Program Administrator
Public Health Statistics
State Office of Vital Statistics

GJS/vlm
Enclosure

VITA

Ma, Fangchao was born in Jiangkou, Hubei Province, China, on November 4, 1963. His parents are Dezhen Li and Mingyu Ma. After finishing high school in 1981, he entered Tongji Medical University in Wuhan, China and was graduated with Bachelor of Medicine degree (M.D. equivalent) in 1986. He studied Biostatistics and Epidemiology at the West-China University of Medical Sciences from 1988 to 1991 and received Master of Medicine degree (M.S. equivalent) in 1991. He received Master of Public Health degree in Epidemiology at the University of Alabama at Birmingham in 1995.

In August 1995 he was admitted to the Graduate School of the University of Miami where he was granted the degree of Doctor of Philosophy in June 2003.