



# Firefighters & Prostate Cancer

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## GENERAL EPIDEMIOLOGY: PROSTATE CANCER

According to the American Cancer Society (ACS), prostate cancer is the second most common cancer in men<sup>1</sup>. They estimate that in 2019 approximately 174,650 men will be diagnosed with prostate cancer in the United States (US), while 31,620 will die from the disease. Prostate cancer develops primarily in older (>65 years) and African-American men. The average age of diagnosis is about 66 years. ***Prostate Cancer is one of the only cancers for which firefighting is listed as a possible risk factor on the American Cancer Society's informational website<sup>2</sup>.***

## INTERNATIONAL AGENCY FOR RESEARCH ON CANCER (IARC)

In June 2022, IARC convened an international meeting of scientists to re-evaluate firefighting as an exposure related to cancer. They determined the literature supports reclassifying ***firefighting to a Group 1 carcinogen (carcinogenic to humans) based on "sufficient" evidence<sup>3</sup>***. This is the ***highest*** classification of exposure only assigned when there is scientific certainty.

Their statement indicated:

***There was also "strong" mechanistic evidence that occupational exposure as a firefighter shows the following key characteristics of carcinogens in exposed humans: "is genotoxic", "induces epigenetic alterations", "induces oxidative stress", "induces chronic inflammation", and "modulates receptor-mediated effects".***

Specific to prostate cancer, IARC ***noted "limited" evidence in humans for prostate cancer as related to firefighting***. While typical use of the word "limited" implies a lack of evidence or support, IARC's classification with the word limited "means that a positive association has been observed between exposure to the agent and cancer but that other explanations for the observations (technically termed "chance", "bias", or "confounding") could not be ruled out with reasonable confidence." ***It should be noted that IARC criteria and classifications are focused on scientific levels of certainty which are more stringent than those focused on the "weight of the evidence"<sup>4</sup> which is often used in cases of workers compensation.***

## GENERAL RISK FACTORS FOR PROSTATE CANCER

While scientists do not know specifically what causes prostate cancer, a number of risk factors have been identified<sup>5</sup>.

- **Age.** Prostate cancer is rare in younger men (age < 40). Risk increases significantly after the age of 50 for Caucasian men and 40 for African American men who have a close relative with prostate cancer.
- **Race/Ethnicity.** Prostate cancer is more prevalent among African-American men and Caribbean men of African ancestry than other men. Prostate cancer occurs less often among Asian-American and Hispanic/Latino men compared to non-Hispanic whites.
- **Geography.** Prostate cancer is more common in North America, northwestern Europe, Australia, and on Caribbean islands. It is less common in Asia, Africa, Central America, and South America.
- **Family History/Genetics.** Prostate cancer tends to run in families, suggesting a genetic component.
- **Obesity.** There is some evidence that there may be a modest increased risk of prostate cancer<sup>5</sup> with obesity although other work has found no increased risk of developing prostate cancer but only increased progression and mortality.

- **Smoking.** It seems that smoking, particularly heavy smoking, likely increases risk for developing prostate cancer<sup>5</sup>.

## **RISK FACTORS PARTICULARLY RELEVANT TO FIREFIGHTERS**

Changes in the DNA of normal prostate cells cause prostate cancer. These DNA changes can either be inherited from a parent or can be acquired during a person's lifetime. According to the ACS, most gene mutations which cause prostate cancer develop during a man's life rather than being inherited.<sup>2</sup> Among the environmental factors hypothesized to cause prostate cancer are high levels of insulin-like growth factor-1 (IGF-1), inflammation of the prostate, exposure to radiation, and (most salient for firefighters) cancer-causing chemicals.

## **CHEMICAL EXPOSURES AMONG FIREFIGHTERS**

Firefighters are exposed to a broad range of chemicals, both in the firehouse and during emergency response. Recent research conducted with live burns have begun to identify and quantify the presence of carcinogens that typically are present on the fire ground. Most alarming are findings that, even when the air appears "clear" there often are ultra-fine respirable particles and gaseous chemicals of several known carcinogens present. Unfortunately, this time period when there is no visible smoke is typically when firefighters remove their personal protective equipment and self-contained breathing apparatus. Particularly noted in the research is the presence of carcinogens such as phthalates, benzene, polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), asbestos, polycyclic aromatic hydrocarbons (PAHs), vinyl chloride and heavy metals<sup>6-13</sup>. These same chemicals have recently been implicated as playing a central role in the development of prostate cancer. Firefighters face several routes of exposure to these carcinogens including inhalation, dermal absorption, secondary exposure through contaminated dust from particulates post incident, and potentially the semi-volatile off gassing of gear

### **Endocrine Disrupting Chemicals**

The Endocrine Society has released two statements over the past decade outlining what have been identified as endocrine disrupting chemicals. These synthetic chemicals include polychlorinated biphenyls (PCBs), plastics (bisphenol A), plasticizers (phthalates), dioxins, and some metals<sup>14,15</sup>. Evidence suggests that these chemicals disrupt normal hormone functioning and interrupt normal homeostatic control and reproduction. As described by Tsai and colleagues<sup>16</sup>, functioning of the prostate is controlled by testosterone, a hormone regulated gland. Synthetic chemicals such as polychlorinated biphenyls (PCBs), plastics (bisphenol A), and plasticizers (phthalates), and some metals are included in the list as known endocrine disruptors which interfere with the androgen metabolism. The resulting disruption elevates the bioavailability of androgen which, in turn, likely leads to the increased risk of prostate cancer.

***Endocrine disruptors have been found to be present as products of combustion on the fire ground.***

- **Phthalates.** These are a group of chemicals used to improve the durability, flexibility, and stability of plastics. These are commonly used in home building materials and home décor such as flooring and blinds<sup>17</sup>. Exposures to these chemicals, which have been found to be present in the fire environment, also have been linked in the literature to prostate cancer<sup>18</sup>.
- **Polychlorinated biphenyls (PCBs).** PCBs are man-made organic chemicals commonly used as coolants, lubricants in transformers, capacitors, and other electrical equipment. While the chemicals have been banned since the late 1970s due to the evidence that they are a probable human carcinogen; however, they remain in product manufactured

prior to the ban and have been found in the fire environment as a product of combustion<sup>19</sup>. Recent work by Shaw and colleagues<sup>20</sup> has found evidence of these chemicals in the blood of California firefighters higher than the general population.

- **Polybrominated Diphenyl Ethers (PBDEs)**. PBDEs are a complex grouping of chemicals present in polyurethane foam in furniture, electronics, plastics, and flame retardants. These chemicals exert effects on hormonal systems and the thyroid systems. Clearly, these products being burned account for the presence of PBDEs on the fire ground.

### **Additional Carcinogen Exposures**

In addition to chemicals noted as EDCs, a number of additional chemicals recognized as known carcinogens to humans and linked to firefighting by the International Agency for Research on Cancer of the World Health Organization are pertinent to the study of firefighters' cancer including benzene and arsenic<sup>19</sup>.

- **Benzene**. Benzene is present as a product of combustion from several standard household materials (e.g. PVC pipe, PVC siding, Christmas trees)<sup>6</sup>, from exposure to diesel exhaust, and has been found to off gas from firefighters' personal protective equipment (PPE)<sup>10</sup> and is widely recognized as a fireground risk. Benzene is not only present on the fire ground as a product of combustion, but also at high rates in many fire stations as trucks and ambulances are housed in the bay areas. While efforts are being made to increase the use of exhaust mitigation devices in the firehouse, their introduction and use is relatively new to the fire service. Exposure to benzene has been found to increase prostate cancer risk<sup>21</sup> particularly for those exposed over a long period of time<sup>22</sup>.
- **Arsenic**. Arsenic, which is has been classified by the IARC as a known carcinogen and present in smoke at fires<sup>19</sup>, also has been found in nearly all areas of a burning home<sup>6</sup>. Research has found that even low level arsenic exposure from drinking water can be related to increased risk for prostate cancer<sup>23</sup>.

### **Shift Work**

Shift work and being exposed to light at night interrupts the typical circadian rhythms of the body. Given the nature of the job and emergency calls, it is not surprising that firefighters – who are faced with a career of 24 hours shifts and emergency calls during the night – struggle with the negative health implications of shift work. Evidence about the impact of these interruptions has led the IARC to classify shift work as probably carcinogenic to humans.

Rao<sup>24</sup> and colleagues conducted a meta-analysis examining whether night-shift work increases the risk of prostate cancer using findings from almost 2.5 million individuals from eight published studies. This study found that **night-shift work was associated with a 24% increase risk for prostate cancer** (RR: 1.24, 95% CI: 1.05 – 1.46; p = 0.011).

In a meta-analysis focused specifically on occupational risk factors and their relationship to prostate cancer, Krstev and colleagues<sup>25</sup> found that **shift work was related to 25% increased risk for prostate cancer** (metaRR=1.25, 95% CI=1.05-1.49). Of note, shift work showed one of the largest associations to the development of prostate cancer of all the variables studied.

### **RISK OF PROSTATE CANCER AMONG FIREFIGHTERS**

Prostate cancer is among the **mostly consistently identified to be at high risk among firefighters** in the scientific literature.

A 2006 meta-analysis by LeMasters and colleagues<sup>26</sup> found a summary risk estimate of 1.28 (1.15-1.43), indicating **firefighters are 28% more likely to get prostate cancer** than the general population. In their discussion, the authors conclude “the meta-analysis and criteria assessment designate the likelihood of cancer among firefighters as probable for multiple myeloma and **prostate cancer**” (pg. 1192).

Subsequent to the LeMasters meta-analysis, several large studies have been conducted with firefighters. In a cohort study, Pukkala and colleagues<sup>27</sup> found a SIR of 1.13 (1.05-1.22) for prostate cancer indicating that **firefighters are 13% more likely to develop prostate cancer** than the general population.

Similarly, Glass and colleagues<sup>28</sup> performed a cohort study among Australian firefighters and found a SIR of 1.30 (1.19-1.43) indicating that **firefighters are 30% more likely to develop prostate cancer** than the general population. A Canadian sample of firefighters found firefighters were at a **18% greater risk** of developing prostate cancer (HR=1.18, 95% CI=1.01-1.37)<sup>29</sup>. Finally, Korean **firefighters were 32% more likely** to develop prostate cancer than the general population (SIR=1.32, 95% CI=0.60-2.51)<sup>30</sup>.

Tsai and colleagues<sup>16</sup> conducted a case-control study among California firefighters and found an Odds Ratio of 1.45 (1.25-1.69) for prostate cancer indicating that **firefighters were 45% more likely to have prostate cancer** compared to matched controls.

Lee et al.<sup>31</sup> examined over 100,000 career Florida firefighters over a 34-year period, identifying 3760 male and 168 female primary cancer incidents using the Florida State Fire Marshall's Office and Florida Cancer Data System. After adjusting for age and year of cancer diagnosis, the authors found **male firefighters had a significantly elevated risk of prostate cancer** (aOR = 1.36, 95% CI = 1.27 – 1.46).

The International Agency for Research on Cancer (IARC)'s 2010 monograph explored the risk of prostate cancer among firefighters and reported a standardized incidence ratio of 1.30 (1.12-1.51) indicating a **30% increased risk of developing prostate cancer among firefighters**<sup>19</sup>.

Recent meta-analytic studies have examined the literature related to prostate cancer and have found an increased risk among firefighters. Jalilian et al.<sup>32</sup> found **that firefighters were 15% more likely to develop prostate cancer** (SIR=1.15, 95% CI=1.05-1.27) but were not more likely to die from it (SMR=1.08, 95% CI=0.92-1.27) compared to comparison groups.

Two additional meta-analyses focused specifically on firefighters and prostate cancer. Mehlum et al.<sup>33</sup> found a summary risk ratio of 1.19 (1.08-1.32) indicating a **19% increased risk of prostate cancer among firefighters**. Similarly, Sritharan and colleagues<sup>34</sup> found an incident meta risk estimate of 1.17 (1.08-1.28) indicating a **17% increased risk of developing prostate cancer** but found firefighters were not more likely to die from prostate cancer than comparison groups (MMRE=1.12, 95% CI=0.92-1.36).

It should be noted that one widely cited cohort study by Daniels and colleagues<sup>35</sup> found an increased incidence of (SMR=1.09; 95% CI=0.96-1.22) and mortality from (SMR=1.03; 95% CI=0.98-1.09) prostate cancer among firefighters. While estimates were not statistically significant, it should be emphasized that published risk estimates likely represent an underestimate of the actual risks of prostate cancer among firefighters for reasons reviewed in this document.

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