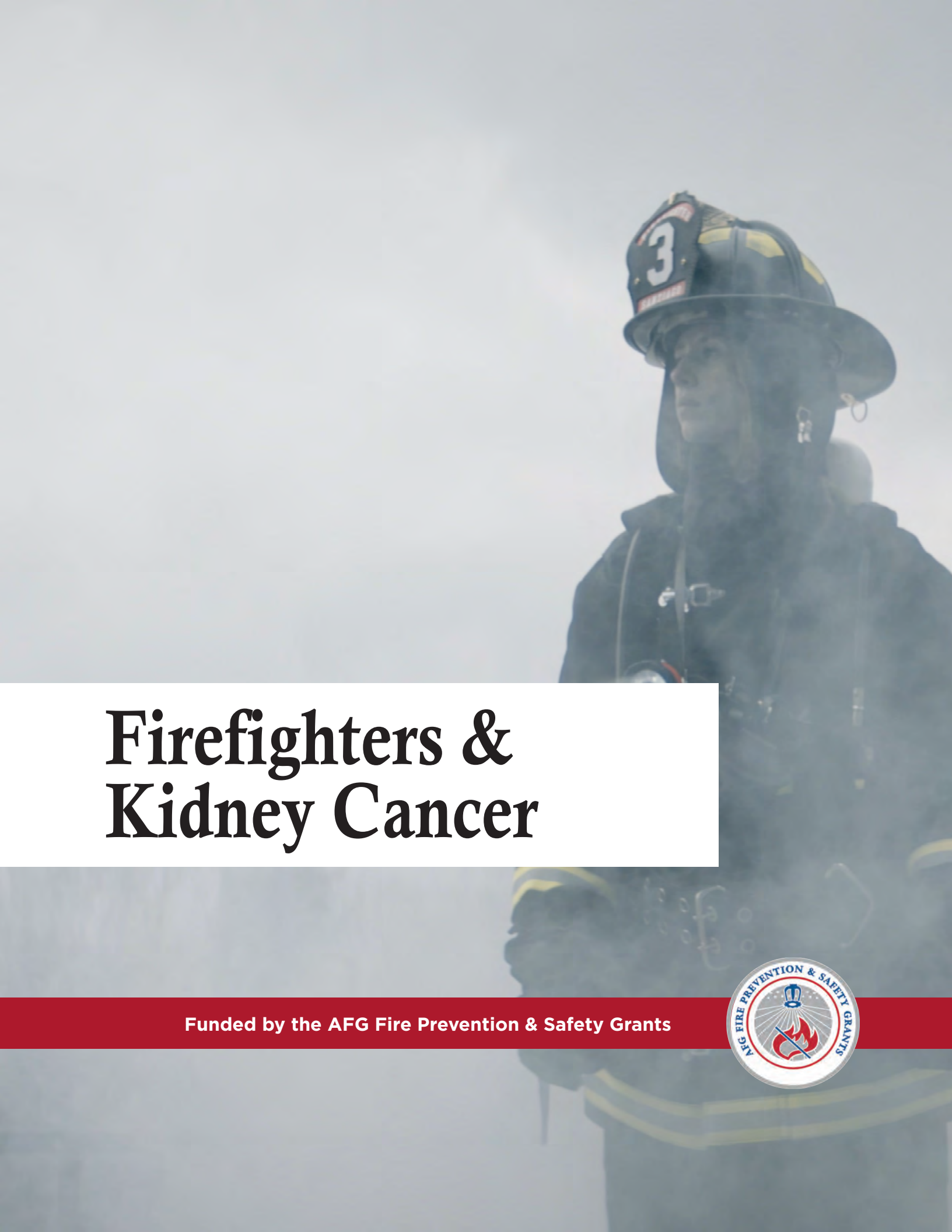

Firefighters & Kidney Cancer

Funded by the AFG Fire Prevention & Safety Grants

2022

Authors:
Walker S. Carlos Poston, Ph.D., M.P.H., FACE
Sara A. Jahnke, Ph.D., FACE
Maria DH Koeppel, Ph.D.
Christopher K. Haddock, Ph.D., PStat®

Center for Fire, Rescue & EMS
Health Research
NDRI-USA, Inc.
New York, NY

The project team would like to acknowledge and thank Captain Robert Webb (Ret., Fort Worth Fire Department) who has been committed to supporting firefighters in understanding their cancers and sharing empirical evidence with them in their time of need. His assistance and review were appreciated by the team and his dedication to supporting his brothers and sisters is an inspiration.

GENERAL EPIDEMIOLOGY: KIDNEY CANCER

Kidney cancer is among the top 10 most common forms of cancer for both men and women[3]. In 2021, the American Cancer Society (ACS) estimated 76,080 new cases of kidney cancer will be diagnosed, while 13,780 will die from it[3]. The lifetime risk for men developing kidney cancer is 1 in 46, while the lifetime risk for women is 1 in 80[3]. Survival rates for kidney cancer vary depending on the stage, although the combined 5 year relative survival rate is 75%[4]. Diagnosed in Stage 1, the survival rate for kidney cancer is 93%; diagnosed at Stage 4, it drops to 13%.

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***[1]. 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".

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"[2] which is often used in cases of workers compensation.

GENERAL RISK FACTORS FOR KIDNEY CANCER

There are a number of risk factors associated with developing kidney cancer:

- **Gender:** Kidney cancer is twice as common in men than in women. This may be due to the higher likelihood of men smoking and being exposed to cancer-causing chemicals at work[5].
- **Race:** African Americans are at a slightly higher risk, however reasons for the elevated risk are unclear[5].
- **Smoking*.*** There is a positive correlation between how much one smokes and developing kidney cancer. The risk does drop if one ceases smoking, although it takes many years to significantly decrease the risk[5].
- **Personal health history*:*** Obesity causes changes in certain hormones leading to an increased risk of kidney cancer. Having high blood pressure, as well as heavy use of acetaminophen, are also linked to an increased risk[5].
- **Workplace exposures*:*** Working in environments where being exposed to certain substances, such as trichloroethylene, increases the risk of kidney cancer[5].

RISK FACTORS RELEVANT TO FIREFIGHTERS

Firefighters are exposed to a broad range of chemicals, both in the firehouse and during emergency response. Recent research conducted with live burns has 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 are often 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 perfluorooctanoic and perfluorooctanesulfonic acids (PFOA and PFOS), phthalates, dioxins, benzene, polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), vinyl chloride, and heavy metals[6–14].

Firefighters face several routes of exposure including inhalation, dermal absorption, secondary exposure through contaminated dust from particulates post incident, and potentially the semi-volatile off-gassing of gear. Many of these same chemicals have been implicated in the development of kidney cancer[15,16].

Arsenic. Commonly found in treated wood used in home construction, arsenic is a common byproduct of combustion on the fire ground[6]. A growing body of evidence suggests that even low levels of arsenic, such as those found in drinking water and well water, lead to increased risk of kidney cancer[17,18].

Per (PFOA). PFOA is recognized by IARC as having limited evidence of being related to the development of kidney cancer[18]. The chemical has been widely used in the manufacture of non-stick cookware, food packaging, and waterproof materials and clothing[19]. The group of chemicals is classified as 2B “possibly carcinogenic to humans” according to the IARC classification system.

Benzo[a]pyrene (BaP). BaP is produced by burning wood and is present in coal tar (such as that on rooftops that burn during a fire) and diesel exhaust. The chemical has the potential to increase risk of kidney cancer[20].

Benzene. Benzene is present as a product of combustion from several standard household materials (e.g. PVC pipe, PVC siding, Christmas trees)[6], from exposure to diesel exhaust, and has been found to off-gas from firefighters’ PPE[10] 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 kidney cancer risk[21].

RISK OF KIDNEY CANCER AMONG FIREFIGHTERS

A number of methodologically sound studies have studied the relationship between melanoma and firefighting and have found increased risks.

In one of the largest single studies of U.S. career firefighters, Daniels and colleagues[22] studied a pooled cohort of 29,993 firefighters from San Francisco, Philadelphia, and Chicago. They found that **firefighters were 27% more likely to be diagnosed with kidney cancer** than the general population (SIR=1.27, 95% CI=1.09-1.48), and **almost 30% more likely to die from kidney cancer** than the general population (SMR=1.29, 95% CI=1.05-1.58).

Additional research continues to find an elevated risk of kidney cancer among firefighters. Tsai et al[23] conducted a case-control study of cancer risk among firefighters in California from 1988-2007 using the California Cancer Registry (CCR). The study included 3,996 male firefighters with cancer and 48,725 non-firefighter controls. **The authors found that firefighters overall experienced a greater risk for kidney cancer** (OR = 1.27, 95% CI = 1.01-1.59) even after adjusting for age of diagnosis, race, and year of diagnosis.

Indiana firefighters were found to be **84% more likely to die** from kidney cancer compared to non-firefighters (OR=1.84, 95% CI=1.17-2.83)[24], while international work found Korean firefighters **were 56% more likely** to develop kidney cancer than the general population (SIR=1.56, 95% CI=1.01-2.41)[25].

References

1. Demers PA, DeMarini DM, Fent KW, et al. Carcinogenicity of occupational exposure as a firefighter. *Lancet Oncol*. 2022;23(8):985-986. doi:10.1016/S1470-2045(22)00390-4

2. Guidotti T. Cancer. In: *Health Risks and Fair Compensation in the Fire Service*. Risk, Systems and Decisions. Springer; 2016.

3. Key Statistics About Kidney Cancer. Accessed November 26, 2021. https://www.cancer.org/cancer/kidney-cancer/about/key-statistics.html

4. Survival Rates for Kidney Cancer. Accessed November 26, 2021. https://www.cancer.org/cancer/kidney-cancer/detection-diagnosis-staging/survival-rates.html

5. Risk Factors for Kidney Cancer. Accessed November 27, 2021. https://www.cancer.org/cancer/kidney-cancer/causes-risks-prevention/risk-factors.html

6. Fabian T, Borgerson J, Kerber S, et al. *Firefighter Exposure to Smoke Particulates*. Underwriters Laboratories Inc; 2010:6.

7. Baxter CS, Hoffman JD, Knipp MJ, Reponen T, Haynes EN. Exposure of Firefighters to Particulates and Polycyclic Aromatic Hydrocarbons. *J Occup Environ Hyg*. 2014;11(7):D85-D91. doi:10.1080/15459624.2014.890286

8. Fent KW, Eisenberg J, Snawder J, et al. Systemic Exposure to PAHs and Benzene in Firefighters Suppressing Controlled Structure Fires. *Ann Occup Hyg*. 2014;58(7):830-845. doi:10.1093/annhyg/meu036

9. Fent KW, Alexander B, Roberts J, et al. Contamination of firefighter personal protective equipment and skin and the effectiveness of decontamination procedures. *J Occup Environ Hyg*. 2017;14(10):801-814. doi:10.1080/15459624.2017.1334904

10. Fent KW, Evans DE, Booher D, et al. Volatile Organic Compounds Off-gassing from Firefighters' Personal Protective Equipment Ensembles after Use. *J Occup Environ Hyg*. 2015;12(6):404-414. doi:10.1080/15459624.2015.1025135

11. Kirk KM, Logan MB. Firefighting instructors' exposures to polycyclic aromatic hydrocarbons during live fire training scenarios. *J Occup Environ Hyg*. 2015;12(4):227-234. doi:10.1080/15459624.2014.955184

12. Kirk KM, Logan MB. Structural Fire Fighting Ensembles: Accumulation and Off-gassing of Combustion Products. *J Occup Environ Hyg*. 2015;12(6):376-383. doi:10.1080/15459624.2015.1006638

13. Robinson MS, Anthony TR, Littau SR, et al. Occupational PAH Exposures during Prescribed Pile Burns. *Ann Occup Hyg*. 2008;52(6):497-508. doi:10.1093/annhyg/men027

14. Jahnke SA, Jitnarin N, Kaipust CK, Hollerbach BH, Naylor BM, Crisp, C. *Fireground Exposure of Firefighters: A Literature Review*. Fire Protection Research Foundation; 2021.

15. Shearer JJ, Callahan CL, Calafat AM, et al. Serum Concentrations of Per- and Polyfluoroalkyl Substances and Risk of Renal Cell Carcinoma. *J Natl Cancer Inst*. 2021;113(5):580-587. doi:10.1093/jnci/djaa143

16. National Cancer Institute. Environmental Pollutant, PFOA, Associated with Increased Risk of Kidney Cancer. Published 2020. Accessed November 26, 2021. https://dceg.cancer.gov/news-events/news/2020/pfoa-kidney

17. Smith AH, Marshall G, Roh T, Ferreccio C, Liaw J, Steinmaus C. Lung, Bladder, and Kidney Cancer Mortality 40 Years After Arsenic Exposure Reduction. *J Natl Cancer Inst*. 2018;110(3):241-249. doi:10.1093/jnci/djx201

18. International Agency for Research on Cancer (IARC). *List of Classifications by Cancer Sites with Sufficient or Limited Evidence in Humans, IARC Monographs Volume 1-130*.; 2021. Accessed March 10, 2022. https://monographs.iarc.who.int/wp-content/uploads/2019/07/Classifications_by_cancer_site.pdf

19. Benbrahim-Tallaa L, Lauby-Secretan B, Loomis D, et al. Carcinogenicity of perfluorooctanoic acid, tetrafluoroethylene, dichloromethane, 1,2-dichloropropane, and 1,3-propane sultone. *Lancet Oncol*. 2014;15(9):924-925. doi:10.1016/S1470-2045(14)70316-X

20. Asha S. Benzo[a]pyrene induced liver and kidney cancer in Swiss albino mice. *Res Pharm*. 2011;1.

21. Hu J, Mao Y, White K. Renal cell carcinoma and occupational exposure to chemicals in Canada. *Occup Med Oxf Engl*. 2002;52(3):157-164. doi:10.1093/occmed/52.3.157

22. Daniels RD, Kubale TL, Yiin JH, et al. Mortality and cancer incidence in a pooled cohort of US firefighters from San Francisco, Chicago and Philadelphia (1950-2009). *Occup Environ Med*. 2014;71(6):388-397. doi:10.1136/oemed-2013-101662

23. Tsai RJ, Luckhaupt SE, Schumacher P, Cress RD, Deapen DM, Calvert GM. Risk of Cancer Among Firefighters in California, 1988–2007. *Am J Ind Med*. 2015;58(7):715-729. doi:10.1002/ajim.22466

24. Muegge CM, Zollinger TW, Song Y, Wessel J, Monahan PO, Moffatt SM. Excess mortality among Indiana firefighters, 1985-2013. *Am J Ind Med*. 2018;61(12):961-967. doi:10.1002/ajim.22918

25. Ahn YS, Jeong KS, Kim KS. Cancer morbidity of professional emergency responders in Korea. *Am J Ind Med*. 2012;55(9):768-778. doi:10.1002/ajim.22068

DetecTogether