

Increased Cancer Diagnoses Among Younger Firefighters

BY AMY GALLAGHER

From fighting wildland fires in rural areas to structural fires in major cities, firefighters in all environments are also fighting hazardous and carcinogenic chemicals that could fill the periodic table of elements—carbon monoxide, sulfur dioxide, hydrogen cyanide, and dichlorofluoromethane, to name a few. And it's not only the chemicals in the fires that generate higher risks of cancer exposure for firefighters; some are concerned that the clothes on their backs and the boots on their feet are equally as harmful.

Recent years of studies have shown carcinogens enter the body of a firefighter by two primary routes: 1) through the lungs when firefighters do not wear or prematurely remove self-contained breathing apparatus (SCBA); and 2) dermal absorption where toxicants are absorbed through the skin, despite the use of personal protective equipment (PPE), including turnout gear.

The National Institute for Occupational Safety and Health (NIOSH) conducted a study among 30,000 career firefighters working between 1950 and 2009 that found a 9 percent increase in all cancer diagnoses and a 14 percent increase in all cancer-related deaths compared with the general population. Some cancers in certain firefighter groups were increased over 100 percent.

New Generation Post 9/11

Since the increase of cancer diagnoses of firefighters of post 9/11, research studies have identified a “new generation of firefighters,” according to

Vershalee Shukla, MD, a radiation oncologist at Vincere Cancer Center in Scottsdale, AZ.

“The biggest difference between cancer diagnoses [pre- and] post-9/11 was the fact that many of the firefighters were smokers,” said Shukla. “Today, however, it’s against policy for firefighters to smoke. We also have increased awareness of cancer exposures and risks among the firefighter population. We have a different generation of firefighters today.”

In 2018, Shukla launched a pilot program screening lung cancer in patients using new ultra low-dose CT scanning technology. Inspired by the 9/11 firefighter lung cancer research studies, Shukla began to question the possibility of conducting low-dose lung CT screening to detect cancers at an earlier stage, notably in younger firefighters, when treatment is more favorable.

“These new CT scans have lower doses of radiation, which can be used in a safe setting,” she said.

New Comprehensive Screening Program

Shukla’s research study, *Low Dose Lung CT Screening in First Responders in the Phoenix Metro Area: A Feasibility Study*,

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was presented at the International Association for the Study of Lung Cancer [IASLC] 2019 North America Conference on Lung Cancer (*J Thorac Oncol* 2019; <https://doi.org/10.1016/j.jtho.2019.08.2225>). The researchers screened 350 Arizona firefighters aged 34-76 who worked for an average of >21 years. Of the 350, results showed 195 firefighters-patients went on to be further screened with low-dose CT, while of the 195 (44.1%), required additional monitoring and/or follow-up after abnormal findings were identified.

“We translated that program to focus on screening firefighters at age 40 and older,” she said. “This also led to our more comprehensive screening program today in which we conduct whole-body MRIs, low-dose scans, colonoscopies, skin assessments, urological exams, and gynecological exams.”

In 2019, Shukla diagnosed 50 different types of cancers in firefighters. All of the firefighters under the age of 45 were diagnosed with cancer, and some of the cancer types included kidney cancer, aggressive testicular cancer, and myeloma.

“The point of this work is that, it’s not only important for our firefighters, it’s important for the general population as well,” said Shukla. “These young cancers are thought to be attributed to environmental exposures. With the knowledge from early screening and studying cancer in our firefighters, this will help diagnose earlier cancers in the general public.”

Improving Screening Guidelines

The only current national lung cancer screening guidelines from the U.S. Preventive Services Task Force (USPSTF) recommend annual, low-dose CT screening in adults aged 55-80 who have ≥30 pack-years of exposure, and who are currently smoking or have quit within the past 15 years.

There are no occupational guidelines recommending low-dose CT in first responders who may develop the disease from occupational exposures, although the firefighter population accounts for approximately 30 percent of lung cancer cases, said Shukla.

Upon learning that firefighters were developing lung cancer before the age of 55—the disease tends to take approximately 20 years to develop after exposures, and many firefighters start their careers at young ages—Shukla lowered her low-dose CT screening age beyond the USPSTF recommended guideline to 40 years.

“We know conducting chest X-rays every 5 years is not adequate, so we are working toward finding an effective, safe alternative,” she noted.

Presumptive Law: Fighting to Protect Firefighters

Cancer, heart disease, lung disease, and infectious disease are among the leading causes of death and disability for firefighters, and numerous studies have found that these illnesses are occupational hazards of the job, according to the International Association of Fire Fighters, in support of the Federal Firefighters Fairness Act and encouraging members of Congress to cosponsor HR 1174 and SB 1942.

In recognition of this link, 46 states have enacted presumptive disability laws, which presume that certain diseases contracted by firefighters are job-related for purposes of workers’ compensation and disability retirement, unless proven otherwise. At present, however, there is not a federal law that protects firefighters



Capt. John Gulotta, Tucson Fire Department

During a fire, chemicals such as smoke-related compounds surround firefighters, including polycyclic aromatic hydrocarbons and flame retardants on firefighters’ skin and gear.



Capt. John Gulotta, Tucson Fire Department

“While there are many known and suspected human carcinogens produced in fires, we don’t know which set of chemicals are the most important affecting the mechanisms that cause cancer,” noted Jeff Burgess, MD, MS, MPH.

tasked with combating fires and mitigating hazardous materials incidents alongside their counterpart firefighters from municipal and state fire departments who are covered by these presumptive disability laws.

As a matter of point, Shulka recently diagnosed two female firefighters with breast cancer at an early stage. She worked to make sure they were covered under Arizona's presumptive law. Arizona is one of the few states that allowed or considered their coverage.

Female Firefighters & Breast Cancer

In order to conduct the research studies to show validity between female firefighters and the exposure to these cancers, Shulka has found a catch-22 of sorts.

"The biggest reason that breast cancer has not been covered in the presumptive law is the low percentage of female firefighters, making it difficult to demonstrate a higher incidence of cancer," she explained. "Ironically, breast cancer is an adenocarcinoma, which is a glandular cancer, and adenocarcinoma of the lung and prostate are both covered by presumptive law."

The Federal Emergency Management Agency (FEMA) provides funding for research to better understand and prevent cancer in firefighters. "FEMA has funded the Fire Fighter Cancer Cohort Study (FFCCS), which is testing other firefighters," she said. "It's a very successful program."

As part of the FFCCS, Shulka is collaborating with Jeff Burgess, MD, MS, MPH, Associate Dean of Research and Professor at the University of Arizona (UA) College of Public Health, to collect urine, blood, and buccal samples of firefighters who are undergoing cancer screening.

"Working with Dr. Burgess and his colleagues at the UA, we are looking at new technologies that can detect cancer from DNA released from cancer cells into the blood," she said. "We are seeking research funding to conduct these liquid biopsies to detect cancer at an earlier stage, which we hope to apply in a clinical setting to identify tumors that need intervention."

Exposure Studies With Federal Agencies

In 2016, the Department of Homeland Security FEMA Assistance to Firefighters Grant awarded \$1.5 million in funding to a team of researchers to establish the FFCCS. The UA Mel and Enid Zuckerman College of Public Health was designated as the lead institution of a research consortium to develop the framework for this long-term study of cancer in firefighters.

"The first grant that we received in 2016 established the overall framework of the FFCCS, which includes measurements of firefighter exposures and cellular changes that lead to increased cancer risk," Burgess noted.

As part of a collaboration among scientists from the UA, University of Miami, NIOSH, Rutgers University, other research institutions and members of the fire service, the research team has subsequently been awarded an additional four grants to expand the FFCCS.

"This prospective study is focused on carcinogenic exposures, effects, and cancer prevention in the fire service, including paid and volunteer firefighters, training instructors, fire cause investigators, wildland-urban interface (WUI) firefighting, airport fire department and stations, and women firefighters," said Burgess.

With over 20 fire departments participating across the country, the five grants to date now address specific groups within the firefighting profession. "This expansive study, now covering multiple projects, was made possible with the creation of the initial framework grant we received in 2016," he stated.

Fire Department Posing Questions

Working with the City of Tucson Fire Department prior to the development of the FFCCS, Burgess and his team at UA were posed three research questions from the fire department: 1) What are the recurring exposures? 2) What are the effects of exposures? and 3) What are effective interventions to reduce exposures?

"To analyze exposure risks, we take a combination of approaches, including measuring chemicals from fires in the urine of the firefight-

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Learning Objectives for This Month's Activity:

After participating in this activity, readers should be better able to: 1. Analyze research related to firefighters' risk of cancer from occupational exposure to known or potential carcinogens.

2. Identify occupational hazards faced by firefighters and recommendations to mitigate the risk from those hazards.

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ers," Burgess said. "A group of chemicals called polycyclic aromatic hydrocarbons (PAHs) are always present in the fire. We measure PAH metabolite urinary levels before and after a fire, then compare the levels to determine the extent of exposures."

But PAHs are not the only chemicals to worry about, even though they are always present. "PAHs are also proxies for all the other chemicals that firefighters are exposed to in a fire," he explained.

Another known group of chemicals, per- and polyfluoroalkyl substances (PFAS), are commonly referred to as "forever chemicals"

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because they are not easily broken down and, therefore, stay in the environment for long periods of time. PFAS are found in fabrics, furniture, and food packaging, but also in firefighting foams and turnout gear, which includes the firefighter's helmet, foam, boots, and jacket—but it is not yet known whether the PFAS from the turnout gear gets into the bodies of firefighters.

“With one of our current grants, we are studying the ‘forever chemicals’ looking at sources of exposure and the potential relationship of PFAS and cancer in firefighters,” Burgess noted.

Navigating a Matrix of Mechanisms

Researchers must navigate multiple factors when conducting their studies, including the type of fire, the specific job task, when the PPE was put on and taken off, when and how the firefighters clean their gear, as well as how the firefighters clean their skin—all can affect the extent of chemicals absorbed internally, said Burgess.

In the Tucson Fire Department study, which assessed inhalation and skin exposure, Burgess and his team discovered that an increased exposure to cancer-causing chemicals was pervasive to all responders at or near the fire.

“We found everyone on the ground, regardless if they were in the structure on fire or not, had increased exposure,” he stated. “Based on these findings, our Tucson firefighter research put new interventions in place to reduce their firefighters’ exposures.”

The interventions included having the fire service vehicle operators wear SCBA and having the building entry team members wash down their turnout gear before removing it after a fire.

“We compared the concentrations of PAHs in the urine before the interventions, and after both interventions were put in place—the vehicle operators wearing SCBA and the entry team’s washdown of their PPE prior to removal—and it resulted in greatly reduced exposures,” he said.

In addition to the external factors involving PPE is the complex process of medical science in identifying the biomarkers to measure the effects of exposure.

Because cancer has a long latency period (30 years) between exposure and the onset of disease, Burgess said biomarkers are needed to measure the early toxicological effects of carcinogen exposure when interventions to prevent disease could be effective.

“While there are many known and suspected human carcinogens produced in fires, we don’t know which set of chemicals are the most important affecting the mechanisms that cause cancer,” he said.

In one study focused on epigenetics, Burgess and his colleagues compared blood from a group of incumbent firefighters to the blood samples of a group of new firefighter recruits, while adjusting for age and other confounders to determine the effect working as a firefighter.

“We adjusted for all of the confounders when comparing the two groups, finding that incumbent firefighters had altered levels of epigenetic markers compared to the new recruits, putting the incumbent firefighters at higher risk for cancer,” he said. “Now, we are in the process of evaluating changes over time in new recruits after they start working as firefighters, and our preliminary results show many of the same epigenetic markers found to be altered in the incumbent firefighters also change over a 2-year period in the new recruits.”

For the next step in the research study, Burgess said the team will take an even deeper look at the relationship between changes in these epigenetic markers over time while assessing the amount of time (years worked) as a firefighter, and simultaneously monitoring the number of fires worked as well as the most recent fire the firefighter worked.

“We still don’t understand which exposures are the most important and the specific cellular mechanisms by which the exposures are causing cancer,” he said. “This information is necessary to determine the best ways to help prevent cancer in firefighters.”

Carcinogens Affecting Firefighters

Carcinogens commonly encountered by firefighters, categorized by the International Agency for Research on Cancer.

IARC Group 1 Agents

(known humans carcinogens)

- arsenic
- asbestos
- benzene
- benzo[a]pyrene
- 1,3-butadiene
- cadmium
- diesel engine exhaust
- dioxin
- formaldehyde
- pentachlorophenol
- polychlorinated biphenyls
- radionuclides
- soot

IARC Group 2A agents

(probable human carcinogens)

- creosote
- dibenz[a,h]anthracene (a polycyclic aromatic hydrocarbon)
- wood combustion products
- shift work affecting circadian rhythm

Agencies in Support of Firefighter Protections

- A National Institute for Occupational Safety and Health (NIOSH) study that included 30,000 career firefighters over a 50-year period discovered a 9 percent increase in all cancer diagnoses and a 14 percent increase in all cancer-related deaths (*Cancer* 2020; <https://doi.org/10.1002/cncr.32721>).
- Lung cancer screening programs for firefighters have been created in San Diego and Boston, and the Centers for Disease Control and Prevention now offers a nationwide registry to track the number and types of fires attended by each firefighter.
- Current legislation for U.S. firefighters includes HR 1174, the Federal Firefighters Fairness Act and the S. 1942, the Federal Firefighters Fairness Act. This legislation would create a rebuttable presumption that cardiovascular disease, certain cancers, and certain infectious diseases contracted by federal firefighters are job-related for purposes of workers’ compensation and disability retirement.

Collaborative Spirit Growing Exponentially

“These are complicated projects, but the most important aspect is working in partnership with the fire departments and with firefighters who are participating in the research teams,” said Burgess. “Firefighters are good problem solvers who operate effectively in complex settings.”

The translational aspect is very rapid, which allows the fire departments to make changes in their standard operating procedures immediately after the research comes out, he said. As part of the research team, Burgess said the firefighters have been trained to know how to collect all of the samples.

The NIOSH-funded study with the LA County Fire Department and the Orange County Fire Authority has collected samples of urine of the firefighters working in dangerous WUI situations that are too dangerous for academics to go into.

“It’s very gratifying to work with the fire service members who are so engaged in this research,” said Burgess. “With the collaborative spirit growing exponentially across the nation, our firefighter colleagues on the research teams serve as co-authors on the research papers with the academic research team members, and then share with other groups, such as other fire departments.” **OT**

Amy Gallagher is a contributing writer.