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Cancer-Related Behavioral Risk Factors Among Volunteer and Career Firefighters Enrolled in the Cancer Assessment and Prevention Study (CAPS) and the Fire Fighter Cancer Cohort Study (FFCCS)

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Abstract

Although nearly two-thirds of U.S. firefighters serve as volunteers, they are rarely included in studies of firefighters' health. The Firefighter Cancer Assessment and Prevention Study (CAPS), a research component of the Fire Fighter Cancer Cohort Study (FFCCS), has enrolled over 600 U.S. volunteer firefighters to help address this gap. This study found a greater prevalence of cancer-related health behaviors among volunteers compared to career firefighters. These behaviors included cigarette smoking, heavy alcohol use, and obesity. While the differences in behaviors varied between U.S. states, all state-level prevalences were higher among volunteer firefighters than career firefighters. The findings of this study support the need to provide volunteer firefighters with overall and targeted health promotion and cancer prevention programs.

Keywords

firefighter; volunteer firefighter; cancer-related health behaviors; research; cancer prevention

Introduction

More than 15 million firefighters serve in 59 high- and middle-income countries worldwide (Brushlinsky, 2021), including over a million in the United States. Firefighters' work and training environments routinely expose them to human carcinogens and other toxicants (Fent et al., 2017; Sparer et al., 2017). Occupational diseases associated with firefighting include sudden cardiovascular events, a leading cause of line-of-duty firefighter deaths (Kales et al., 2007), and some types of cancer (DeBono et al., 2023). Recently, the International Agency for Research on Cancer (IARC) classified firefighting as carcinogenic to humans (IARC, 2023). This determination was supported by findings demonstrating that the types of exposures incurred by firefighters can cause biological changes that lead to carcinogenesis; studies of cancer in humans showing increased risk for mesothelioma and bladder cancer; and emerging evidence for increased risk for melanoma of the skin, non-Hodgkin's lymphoma (NHL), and cancers of the colon, prostate, and testes. The IARC Working Group indicated that the findings are relevant to all firefighters who train for and take part in fire control activities, including those who serve as volunteers (Demers et al., 2022).

About two-thirds (65%) of U.S. firefighters serve as volunteers (Fahy et al., 2022). Volunteer firefighters receive the same basic training and perform the same duties as career firefighters. While career firefighters respond to calls as assigned by their employers, volunteer firefighters typically choose which calls they respond to, within the framework of their department's rules. Career firefighters usually work in extended shifts (e.g., 24 or 48 hours) during which they reside at their fire station. In contrast, most volunteer firefighters respond to calls from their workplaces, homes, or other locations.

In 2020, there were 29,425 active fire departments in the United States (Fahy et al., 2022). Most of these departments (64%) were comprised entirely of volunteer members, and

18% were classified as combination departments, which consisted primarily of volunteer members and at least some career firefighters (Fahy et al., 2022). Members of other departments were all or mostly career firefighters. While a majority of U.S. firefighters are volunteers, all-volunteer or mostly volunteer fire departments serve less than one-third of the U.S. population. This is because most volunteer fire departments serve less densely populated rural and suburban communities, while most career fire departments serve densely populated urban centers (Fahy et al., 2022).

While there is a robust literature evaluating cancer risk in firefighters (DeBono et al., 2023), few studies have included volunteer firefighters. This exclusion is likely due to the convenience of working with career firefighters during their shifts. Researchers working with career firefighters may also be able to access electronic employment records through the fire department or union. In some cases, researchers may also access historical occupational health records. The few studies of cancer incidence among volunteer firefighters suggest some increased risk for cancers of the prostate, rectum, kidneys, and testes (Glass et al., 2017, 2019; Pedersen et al., 2019; Petersen et al., 2018). Further, the contribution of firefighting to cancer rates may be challenging to interpret because U.S. cancer rates differ by rurality. Rural residents have higher rates of colon, rectum, and lung cancers, while urban residents have higher rates of prostate cancer and malignant melanoma (Zahnd et al., 2018).

Volunteer firefighters report responding to fewer calls than their career counterparts in the short term, but they spend more years in the fire service. Volunteer departments may have limited access to high quality and properly maintained protective equipment, infrastructure for health and safety, and routine health exams. Compared to career firefighters, volunteer firefighters appear to have different behavioral risk factors that contribute to cancer risk, including the two modifiable factors that contribute most to cancer incidence and mortality in the general population: tobacco use (Phan et al., 2022) and alcohol use (Haddock et al., 2012; Haddock et al., 2017). However, few studies have assessed these risk factors in a diverse population of volunteer firefighters.

The lack of information on how occupational and behavioral health risks vary between volunteer and career firefighters and between volunteer firefighters in different geographical areas, are important research gaps. These gaps impede the appropriate design and implementation of health promotion and disease prevention programs aimed at reducing cancer risk and improving the overall health of volunteer firefighters. The Fire Fighter Cancer Cohort Study (FFCCS; www.ffccs.org) is a national platform to study cancer and mechanisms of carcinogenesis among career firefighters that was established in the United States in 2016. In this article, we first describe the methodology and preliminary results from the Firefighter Cancer Assessment and Prevention Study (CAPS). CAPS is a research component designed by the FFCCS to involve volunteer firefighters in cancer etiology and prevention research and to address this research gap. Secondly, we present findings on the prevalence of cancer-related health behaviors from enrollment surveys of the volunteer firefighters enrolled in CAPS and the career firefighters enrolled in the FFCCS between November 2019 and January 2023.

Methods

CAPS: Formation and Approach

The CAPS was initiated in response to concerns raised by volunteer firefighters about their cancer risk and the lack of research involving volunteer firefighters addressing this issue. Leaders from a large suburban volunteer fire department in New Jersey engaged with the administration and researchers at Rutgers, the State University of New Jersey, to focus on these concerns. Together they convened a multidisciplinary working group that included firefighters as well as researchers with expertise in occupational and environmental exposure assessment, medicine, epidemiology, and research design and implementation. Fire service leaders and researchers held a series of meetings in the spring and summer of 2018, resulting in a pilot project with two overarching aims: (a) to establish a long-term partnership with volunteer fire departments to jointly conduct cancer research and prevention activities, and (b) to characterize factors that may be linked to increased cancer risk among volunteer firefighters, including fire service-related activities, health behaviors, and occupational exposures. The team received mentoring and technical assistance in study design and implementation from the FFCCS leadership. In 2019, the team applied for and was awarded a 3-year grant from the Federal Emergency Management Agency's Fire Prevention & Safety (FP&S) program to develop the CAPS and enroll volunteer firefighters into the FFCCS.

FFCCS: Formation and Approach

The FFCCS was established in 2016 as a multicenter prospective cohort with two aims: (a) to characterize exposures and mechanisms that contribute to increased cancer risk among US firefighters, and (b) to inform and apply evidence-based cancer prevention strategies in partnership with all sectors of the U.S. fire service. The study seeks to enroll 10,000 firefighters and follow the study participants for up to 30 years. The FFCCS involves collection and integration of information from surveys, exposure measurements, and biological samples (predominantly blood and urine) at entry into the study and approximately every two years after enrollment.

The FFCCS follows community-engaged research principles, engaging fire service partners in study design, implementation, data interpretation, and dissemination. Some firefighter research partners complete formal human subjects research protection training, enabling them to engage in research activities such as enrollment of firefighters into the cohort, oversight of survey administration, and biological specimen collection.

FFCCS and CAPS Eligibility

Eligibility requirements for the CAPS and the FFCCS include being an active firefighter or a new recruit with volunteer or career status. The CAPS enrollees were members of a volunteer or combination fire department. The participants were at least 18 years old and able to complete the consent process and surveys in English.

CAPS Enrollment

A convenience approach was employed to identify interested fire departments, leveraging partnerships with fire service organizations including the National Fire Protection

Association (NFPA) Fire Protection Research Foundation, the National Volunteer Fire Council, and the International Public Safety Data Institute. The CAPS study enrollment process is outlined in Figure 1. The CAPS researchers contacted the leadership of these fire departments by email or phone to explain the study aims. If an email was sent, it included a flyer that expanded on study aims and procedures. Subsequent dialogues between the CAPS research team and the department leadership were held to further review study aims and procedures, to answer questions from the fire department, and to learn more about the department's attributes (i.e., membership and meeting/training schedules).

During these conversations, a liaison from the fire department was identified to serve as the primary research contact. This person, called the CAPS liaison in our study, was often a fire department chief, another senior officer, or a health and safety officer. Dates were then scheduled for the study team to visit the fire department during regular membership meetings on weekday evenings, first for an information session and later for a study recruitment event. Volunteer and combination fire departments typically hold at least one required membership meeting a month, as well as one or more training sessions. The CAPS researchers also used snowball sampling by asking about other local fire departments that might be interested in participating. The CAPS liaisons often identified other fire departments within their existing mutual aid networks for researchers to contact about possible study participation.

The CAPS informational sessions were conducted at the department's or company's fire station. During these informational sessions, the CAPS Principal Investigator (PI) and/or Study Coordinator gave a presentation reviewing the study rationale, aims, eligibility criteria, and procedures. They emphasized that, despite interest from fire department leadership, enrollment into a research study was an individual's choice. Data security measures, including the storage of participant data in a secure system behind the university firewall, the roles and protections afforded by the Institutional Review Board, and the Certificate of Confidentiality, were also explained. Time was given for questions during and after the presentation.

One to two weeks before the study event, an email was sent to the CAPS liaisons, inviting their fire department members to enroll in the CAPS. The liaison distributed the email to their fire department membership. The consent process and survey could be completed online prior to or during the study event. At study enrollment events, the CAPS PI and/or Study Coordinator gave a short presentation that reviewed the material from the information session. The research team set up five stations:

1. Check-in and enrollment: Fire department members could complete the informed consent process. Participants were given an envelope with labels for each of the stations that research team members used to track completion of the study components when participants checked out.
2. Survey: Laptops and tablet computers were set up for participants to complete the survey. Research staff were available to provide technical assistance for participants, if needed.

3. Phlebotomy: Procedures for biological specimen collection are described elsewhere (Graber et al., 2021).
4. Urine collection.
5. Checkout: Study staff confirmed that all study procedures had been completed, answered any questions, and offered participants a t-shirt.

Enrollees were offered a t-shirt with the CAPS and the FFCCS logos (see Figure 1). The CAPS-participating fire departments were given a one-time donation of \$500 to use for educational or training purposes in recognition of the administrative burden involved in study participation. Study team members were available to answer any questions that participants had throughout the enrollment process.

FFCCS/CAPS Survey

The FFCCS survey assesses cancer-related health behaviors, cancer screening behaviors, health care access and use, occupational history, and firefighting history. The survey was originally designed for career firefighters. The CAPS team adapted survey questions, as needed, so they were applicable to volunteer firefighters. Specifically:

- The occupational history section was expanded to include questions about the respondent's primary job and the number of hours worked per week to classify full and part-time employment.
- Questions on the duration of fire service were expanded to include the year the respondent started and ended (if applicable) working as a volunteer firefighter and to secure information about any career firefighting service.
- Questions about shift structure were adapted to capture the number and types of fire-service calls responded to in a typical month.

The survey was implemented using REDCap (Harris et al., 2019) and took most respondents between 30 and 45 minutes to complete.

Measures

Fire service measures included years of volunteer and career firefighting service; accounting for any overlap or gaps; current rank categorized as firefighter, company officer, or chief officer; and the average number of fire department calls responded to per month. For the latter, career firefighters' average monthly calls were calculated based on participant-reported shift schedules. The shift schedule type was used to estimate the number of shifts per month, then that number was multiplied by the calls responded to per shift.

The size of the community that the fire department served was obtained from population estimates from the 2020 U.S. Census (The Redistricting and Voting Rights Data Office, 2023). Firefighters were assigned to the states of their fire department. Three states—Missouri, Kansas, and Illinois—were combined due to the small number of participating firefighters in these states and the demographic similarities among the communities they served.

For comparisons between career and volunteer firefighters, health behavior measures included cigarette smoking and smokeless tobacco use, hazardous alcohol consumption, physical activity level, and body mass index (BMI). Cigarette smoking and smokeless tobacco use were classified as current, former, or never. To classify hazardous alcohol consumption for FFCCS participants, alcohol use was dichotomized as screening positive or negative for hazardous drinking based on the number of drinks consumed per week: > 7 drinks for women and > 14 drinks for men. For the CAPS participants, hazardous drinking was defined based on the Alcohol Use Disorders Identification Test-Concise (AUDIT-C), scoring ≥ 3 for women and ≥ 4 for men. Routine physical activity level was defined using the physical activity rating (PAR) scale, an 8-point, self-rating of physical activity type and duration over the previous 30 days. The PAR scores are interpreted as inactive (PAR 0–1), moderately active (PAR 2–3), and vigorously active (PAR 4–7) (McArdle, 2014). BMI was calculated from self-reported height and weight and categorized as normal/healthy (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obese (≥ 30.0 kg/m²). No participants had a BMI classified as underweight (<18.5 kg/m²).

Statistical Analysis

FFCCS enrollment resulted in an overrepresentation of both Hispanic and female firefighters. To adjust the FFCCS data distribution to that of the U.S. career fire service, employed firefighters were identified in the U.S. Census Bureau's 2021 Current Population Survey (CPS). Sample weights were developed based on the age, sex, and race-ethnicity distribution and applied to the FFCCS data (The Redistricting and Voting Rights Data Office, 2023). Demographic, firefighting, and health behavior characteristics of all the CAPS volunteer firefighters and FFCCS career firefighters were described using the median and interquartile range (IQR) for continuous data and the percent with 95% confidence interval (95% CI) for categorical data.

The distribution of age, sex, and race-ethnicity varied by state for volunteer firefighters (see Table 2, p. 29). Therefore, the prevalence of behavioral characteristics (current cigarette smoking, current smokeless tobacco use, hazardous alcohol consumption, and obesity) were estimated using the random effects logistic regression models, adjusting for age, sex, and race-ethnicity as fixed effects. Fire department was included as a random effect to account for the possible within-fire-department correlation. Additionally, because of differences in age distribution (17% of the CAPS enrollees and 1% of the FFCCS enrollees were over age 60), state-level analyses were restricted to firefighters between the ages of 18 and 60. Adjusted prevalences were reported by state. For career firefighters, multiple imputation was used to impute the missing data, which were assumed to be missing at random (Mack et al., 2018). Adjusted prevalence estimates were derived from the mixed-effect logistic regression model on each of the imputed data sets and pooled together using Rubin's rule (Little & Rubin, 2002; Liu & De, 2015). Models for predicting physical activity at the state level did not converge due to skewed distributions, so they are not presented. The states with 50 or more enrolled firefighters were included in state-level analyses.

Results

Between January 1, 2019, and January 31, 2023, over 40 volunteer and combination fire departments from nine states (CT, IL, KS, MD, ME, MO, NJ, TN, WA) participated in the CAPS. Most participants enrolled through study events at their fire stations. Exceptions included one fire department each in southern Maine and middle Tennessee whose leadership held a study event for several rural departments located nearby. One fire department each in New Jersey and Illinois held the events at their local fire academies.

Of the 607 volunteer firefighters enrolled into the FFCCS through CAPS, 569 are included in this study. Thirty-eight of the original enrollees were excluded for not being a full fire department member (e.g., new recruit, $n = 25$) and not completing the survey ($n = 13$). CAPS researchers received records for 2,909 career firefighters enrolled into the FFCCS under a data use agreement. Working with FFCCS data managers, an analytical sample of 1,573 career firefighters was constructed after removing new recruits, duplicate records, records missing date of birth, participants who enrolled outside the study period, and those who withdrew without completing the survey (see Figure 2).

On average, volunteer and career firefighters spent a similar number of years in the fire service (14 and 12 years, respectively), but volunteers responded to a fifth of the calls per month that their career counterparts responded to (10 vs. 50). All volunteer firefighters enrolled through the CAPS served in communities with fewer than 100,000 people, whereas most career firefighters served in communities with over a million people. Forty percent of enrolled volunteers, but fewer than 1% of career firefighters, served communities with 10,000 or fewer people. Both the CAPS volunteer firefighters and the FFCCS career firefighters were predominantly non-Hispanic White (91% and 79%, respectively) and male (90% and 96%, respectively). Compared to the career firefighters, the volunteer firefighters had less education and lower incomes. A higher proportion of volunteers compared to career firefighters had a high school education or less (25% vs. 9%), and a lower proportion had an annual household income over \$75,000. Over 80% of volunteer firefighters were employed, and over two thirds worked full-time (see Table 1).

Among volunteer firefighters, demographic and firefighting characteristics varied by state. Average years of service ranged from 9 (WA) to 20 (NJ), and the average number of monthly firefighting call responses ranged from 5 (TN) to 25 (WA). There was over a decade of difference in the average age of enrollees, from 34 years old (WA) to 47 years old (NJ) (see Table 2).

Compared to career firefighters, volunteer firefighters had a higher prevalence of current cigarette smoking (10% vs. 1%), but their use of smokeless tobacco was similar (10% vs. 11%). The prevalence of hazardous drinking was over 2.5 times higher in volunteers than their career counterparts (36% vs. 13%). Compared with career firefighters, volunteers had almost double the prevalence of obesity (43% vs. 23%) and a 3 times higher prevalence of being physically inactive (24% vs. 8%) (see Figure 3, p. 30).

State-level analyses are not displayed for Colorado (career), Connecticut (volunteer), and Maryland (volunteer), due to sample size. After adjustment for age, sex, and race-ethnicity,

health behavior prevalence estimates varied substantially by state, with current cigarette use and heavy drinking varying more for volunteer than career firefighters. Among volunteer firefighters, the prevalence of current smoking ranged from none (WA) to 36% (TN). Among career firefighters, the prevalence was 1% or lower. In contrast, there was considerable variation by state in the proportion of both volunteer and career firefighters who currently used smokeless tobacco. The prevalence estimates varied more than five-fold: for volunteers 2% (NJ) to 13% (IL, MO & KS) and for careers 4% (FL) to 14% (CA). The prevalence of hazardous drinking appeared to vary more among volunteer firefighters (24% [TN] to 51% [NJ]) than among career firefighters (22% [MA] to 32% [FL]). The prevalence of obesity varied less by state for both groups of firefighters, but all state-level prevalence estimates for volunteer firefighters were higher than those of career firefighters (see Figure 4, p. 31).

Discussion

Tobacco use is the preventable factor with the highest population attributable risk for cancer in the U.S. general population. Tobacco smoking causes cancer in most organs of the body such as the bladder and colon, sites known to be at a higher cancer risk among firefighters. Smokeless tobacco causes cancer of the oral cavity, esophagus, and pancreas. Tobacco use also incurs other health risks, including exposure to nicotine, the addictive ingredient in tobacco. Nicotine can increase blood pressure and cholesterol levels, thereby increasing the risk of cardiovascular disease.

In 2020, the Centers for Disease Control and Prevention (CDC) estimated that 13% (95% CI: 11.9, 13.0) of U.S. adults currently smoked cigarettes, and 2.3% (95% CI: 2.1, 2.6) currently used smokeless tobacco. Both smoking and smokeless tobacco use have declined among career firefighters since the early 1990s. While smoking prevalence among firefighters has consistently been lower than among other occupational groups (Phan et al., 2022), the proportion of firefighters who use smokeless tobacco has been much higher than that of the general population. In our study overall, 8.8% of volunteer and 10.6% of career firefighters currently used smokeless tobacco. This is consistent with a study by Jitnarin et al. (2013) that surveyed 353 male career firefighters in Missouri between May 2008 and May 2010. That study found that 13% of respondents were current smokeless tobacco users.

According to 2020 data (Cornelius, 2022), current smoking and smokeless tobacco use in the U.S. general population is higher among men than women (smoking: 14.1% vs. 11.0%; smokeless tobacco use: 4.5% vs. 0.3%). Tobacco use is also higher among people living in rural areas than among people living in urban areas (smoking: 19.0% vs. 11.4%; smokeless tobacco use 5.9% vs. 1.7%). In our study, over 90% of volunteer firefighters were men, and almost two thirds served communities with 25,000 or fewer people. The distribution of smokeless tobacco use in the general population may, in part, account for the proportion of smokeless tobacco users observed among the more rural volunteer firefighters. In occupations where smoking is prohibited, other forms of tobacco, including smokeless tobacco, may be used in higher proportion as a way to facilitate nicotine addiction through non-combustible alternatives (Graber et al., 2016). No matter the root causes of smokeless tobacco use among firefighters, prioritizing efforts to reduce its use in the fire service may provide substantial reduction in cancer risk.

In many U.S. states, tobacco smoking is restricted or prohibited by the terms of employment for firefighters. This is consistent with our finding that few career firefighters reported being current cigarette smokers. However, the underreporting of smoking by those career firefighters for whom not smoking is a condition of employment may also contribute to the observed difference in smoking prevalence. In contrast, smoking prevalence among volunteer firefighters in our study was more like that of the general population. While smoking is also prohibited in many volunteer fire departments, the impact on smoking behaviors is likely reduced for volunteers compared to career firefighters, as volunteers spend less time in their fire stations.

Alcohol is a human carcinogen (Baan et al., 2007) and is associated with cancer of the head and neck, breast, pancreas, liver, colon, and rectum. Consistent with other studies, a higher proportion of both volunteer and career firefighters in our study screened positive for hazardous drinking and alcohol use disorder. Hazardous drinking was highly prevalent among both career and volunteer firefighters. To date, there are relatively few studies reporting alcohol use among firefighters. Haddock et al. (2015) studied 954 male career firefighters enrolled from 20 fire departments in 14 U.S. states. Over 85% of the firefighters consumed alcohol, and 45% reported heavy drinking. Heavy drinking was defined for this study as an average of three or more drinks a day. Half of the firefighters in the study (50.2%) reported at least one heavy drinking episode in the past 30 days, which was defined as 5 drinks or more on an occasion. By comparison, about 13% of U.S. men, age 18 and older, screen as having alcohol use disorder (National Institutes of Health, 2023).

Physical fitness is more than a requisite for firefighters to perform their duties. Physical fitness is associated with reduced risk of cancers of the bladder, prostate, and rectum, as well as melanoma and lymphoma (Robsahm et al., 2017). Obesity is a key indicator of poor physical fitness and associated with many types of cancer, including cancers of the digestive and hematopoietic systems (National Institutes of Health, National Cancer Institute, 2023). Our findings are consistent with other studies showing that, after adjusting for age, the prevalence of obesity in male career firefighters was similar to that of the general population (33% vs. 34%). Volunteer firefighters had a larger prevalence of obesity (39%) than career firefighters or the general population (Poston et al., 2011).

This study has some limitations that should be considered when interpreting the findings. The CAPS and the FFCCS used convenience sampling to identify fire departments interested in this collaborative research project. This sampling approach may have introduced selection bias, as it is likely that fire departments with leadership and members who are aware of health issues related to the fire service were more likely to participate than departments with less awareness. As a result, fire departments with a strong culture of health promotion may have enrolled in the study more often than those without this culture. If this is the case, our results may underestimate the prevalence of adverse health behaviors. Another limitation was for the enrolled FFCCS career firefighters. Some variables had a considerable amount of missing survey data. Fifty-nine percent (59%) of the responses from the FFCCS firefighters were missing information for at least one study variable, compared to 12% of the responses from the CAPS firefighters. We used multiple imputation, a robust statistical technique, to estimate these values. There were fewer missing data for the variables included to estimate

the adjusted prevalence estimates. Seventeen percent (17%) of the FFCCS participants and 2% of the CAPS participants included in these analyses had one or more missing values.

An additional consideration is that, unlike career fire service members, volunteer fire department members do not retire. These firefighters tend to remain a volunteer member with reduced response activities, such as assisting with crowd control at fire scenes. We restricted our state-level comparisons to firefighters aged 60 and under to address this discrepancy. Additionally, the definitions used to classify heavy drinking differed between the FFCCS and the CAPS surveys. This may account for some of the observed differences between career and volunteer firefighters. Finally, the reasons that career firefighters had a higher average household income and more years of formal education are unclear, but they may reflect geographic differences in the CAPS and the FFCCS enrollments. Despite these limitations, our study expands health research on volunteer firefighters by integrating and consolidating multiple influencers of firefighter health and by including firefighters from across the United States.

Our study quantified important differences in the distribution of cancer-related health behaviors among career and volunteer firefighters. Equally important, we saw considerable variation in these health behaviors among both career and volunteer firefighters at the state level. These differences have implications for health promotion and cancer prevention activities. They emphasize the need to first understand health behaviors within a given department when planning tailored health promotion interventions. In addition to improving firefighter health and safety, such interventions have the potential to change department culture, attract new members, and improve membership retention. These findings also highlight the importance of engaging with firefighters as research partners and including volunteer firefighters in studies of firefighter health.

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health (NIOSH) at the Centers for Disease Control and Prevention (CDC).

Biographies

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Taylor M. Black, M.P.H., was the founding Project Coordinator for the CAPS. Taylor holds a master's degree in Public Health from Rutgers, The State University of New Jersey. As the CAPS Project Coordinator, she helped develop and implement a framework to support collaboration between the CAPS researchers and fire service partners. She is one of the researchers who founded the CAPS.

Kathleen Black, Ph.D., is a senior program manager at Rutgers Environmental and Occupational Health Sciences Institute. She works with researchers and research-engaged community members on study design and implementation to ensure human subjects' protections, including the development and maintenance of procedures to protect data confidentiality and federal certificates of confidentiality. She is one of the researchers who founded the CAPS.

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Maria D. H. Koeppel, Ph.D., is an associate research scientist for the Center for Fire, Rescue, and EMS Health Research at the National Development & Research Institutes (NDRI)-USA, Inc. She received her doctorate in criminal justice from Sam Houston State University, where she worked for the Crime Victims' Institute and the Correctional Management Institute of Texas. Prior to joining NDRI-USA, Maria worked as a full-time firefighter, a position she now holds on a part-time basis. She is the lead researcher for the CAPS in Missouri and Kansas.

Sara A. Jahnke, Ph.D., is a senior scientist with the Center of Fire, Rescue, and EMS Health Research at NDRI-USA. She has over a decade of research experience on firefighter health. Her work has focused on a range of health concerns, including the health of women firefighters, behavioral health, risk of injury, cancer, cardiovascular risk factors, and substance use. She is also co-lead of the FFCCS and co-director of the FFCCS Data Coordinating Core.

Elena Austin, Sc.D., is an assistant professor in the Department of Environmental and Occupational Health Sciences at the University of Washington. She works to develop methods to jointly investigate exposures to mixtures of pollutants on human health with a particular focus on understudied populations. She is the lead researcher of the CAPS in Washington state.

Michael B. Steinberg, M.D., is a professor, the interim chair in the Department of Medicine, chief in the Division of General Internal Medicine, and vice-chair for clinical research at Rutgers Robert Wood Johnson Medical School. His research includes various cancer prevention methods and evaluating tobacco treatment interventions. He is one of the researchers who founded the CAPS.

Miriam M. Calkins, Ph.D., is a research industrial hygienist at the U.S. Centers for Disease Control and Prevention, National Institute of Occupational Health and Safety, Division of Field Studies and Engineering. Her research focuses on the effects of heat stress and exposures to per- and polyfluoroalkyl substances (PFAS) on firefighters and other workers. She is co-lead of the Fire Fighter Cancer Cohort Study (FFCCS) and co-director of the FFCCS Exposure Assessment Core.

Alberto J. Caban-Martinez, Ph.D., D.O., is the Associate-Vice Provost for Research Integrity, Regulatory Affairs and Assessment at the University of Miami. He is also a tenured professor of public health sciences, orthopedics, physical medicine, and rehabilitation, and Vice-Chair for Research in UM's Department of Public Health Sciences. Trained in occupational health and safety and occupational epidemiology, he is also board certified in public health. Dr. Caban-Martinez works to provide rigorous scientific evidence on occupational health and translate it into the prevention of occupational diseases, including firefighter-related cancers. He is the Co-Deputy Director of the national Firefighter Cancer Initiative at the Sylvester Comprehensive Cancer Center and a co-founder of the FFCCS.

Kaleigh Hinton, M.P.H., is currently pursuing her doctorate in epidemiology at the University of North Carolina, Chapel Hill, Gillings School of Global Public Health. She conducted her MPH research in the CAPS and was the CAPS Study Coordinator from 2022–2023.

Katherine A. Lubina, M.S., is a Ph.D. candidate in epidemiology at the Rutgers School of Public Health. Her research focuses on investigating exposure to per- and polyfluoroalkyl substances (PFAS), and blood lipid levels, including cholesterol, among U.S. volunteer firefighters. She is a member of the CAPS research team and, in addition to her research, leads the development of the CAPS newsletters.

Samantha P. Metlitz, M.P.H., earned a master's degree in public health in epidemiology from Rutgers University in 2021 and has previous experience working as an industrial hygienist. She is currently the Study Coordinator for the CAPS.

Casey Grant, P.E., recently retired from his position as Executive Director of the Fire Protection Research Foundation (FPRF). FPRF is the research affiliate of the National Fire Protection Association (NFPA). He is a Fellow of the Society of Fire Protection Engineers and the Institute of Fire Engineers and was the Secretary of the NFPA Standards Council and Assistant Chief Engineer. In his role in the FPRF and since that time, Casey has provided technical assistance and advice to the CAPS. He is a co-lead of the FFCCS and co-director of the FFCCS Oversight and Planning Board (OPB).

Russell F. Osgood has been in the fire service for over 35 years and is currently the chief of the Ogunquit (Maine) Fire Department. He has been in the forefront of the fire service cancer epidemic since 2011 and was a key developer of the Firefighter Cancer Support Network. He is a co-lead of the FFCCS and co-director of the FFCCS Oversight and Planning Board.

John Gulotta, Captain, has been in the fire service since 1988. He joined the Tucson Fire Department (TFD) in 1997 and became the first captain to hold the position of Health and Safety Program Coordinator within TFD. Since 2015, he has collaborated with the University of Arizona and other researchers to examine the link between occupational toxins in firefighters and increased rates of cancer and to develop best practices for cancer prevention. He is a founder of the FFCCS and serves on the FFCCS Oversight and Planning Board.

Brian S. Kubiak, M.B.A., began his career in emergency services in 1974. He first served as a firefighter, then climbed the ranks to Fire Chief of Toms River Fire Company, No. 1. He was the District Fire Chief at Toms River prior to his promotion in 2011 to Chief Administrator. He is licensed in the State of New Jersey as a Fire Official, Fire Subcode Official, and Fire Inspector HHS. He is the founder of the CAPS and serves on the CAPS Volunteer Firefighter Advisory Board.

Jefferey L. Burgess, M.D., is a professor in the Community, Environment & Policy Department at the University of Arizona. He is trained as an emergency physician, medical

toxicologist, and occupational and environmental medicine physician. His occupational research projects have been focused on reducing toxic exposures and preventing injuries and illnesses among firefighters, other first responders, and miners. He is the director of the FFCCS.

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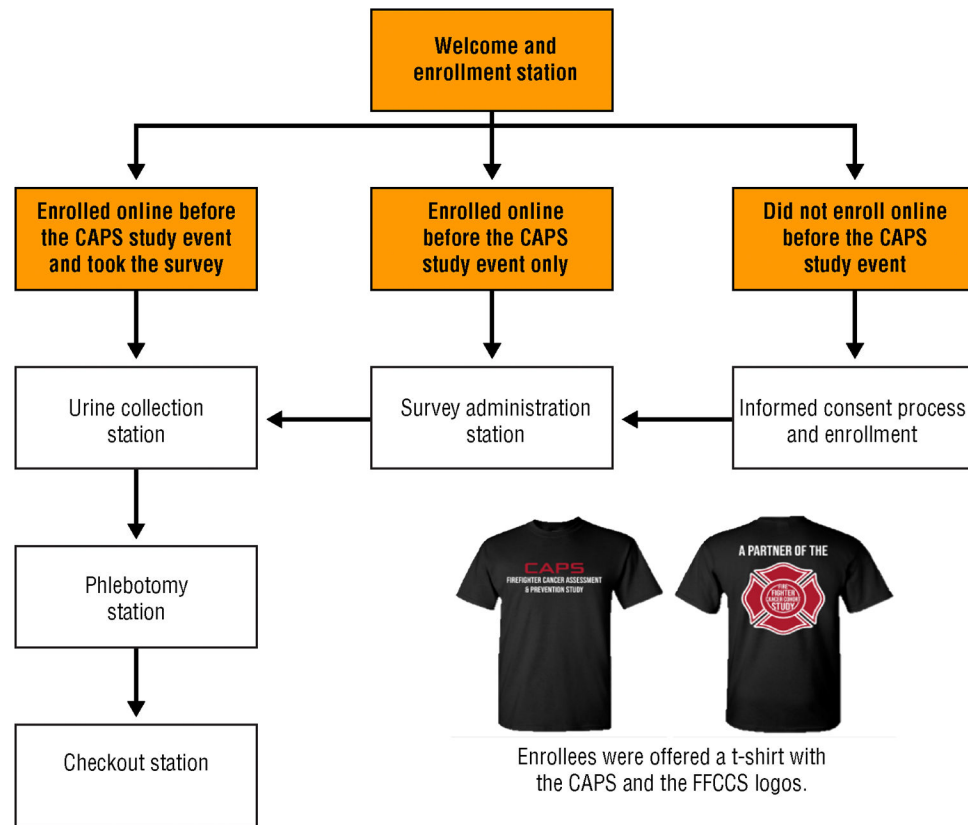


Figure 1.
Cancer Assessment and Prevention Study (CAPS) Enrollment and Data Collection Flow
During Study Visits at the Fire Station

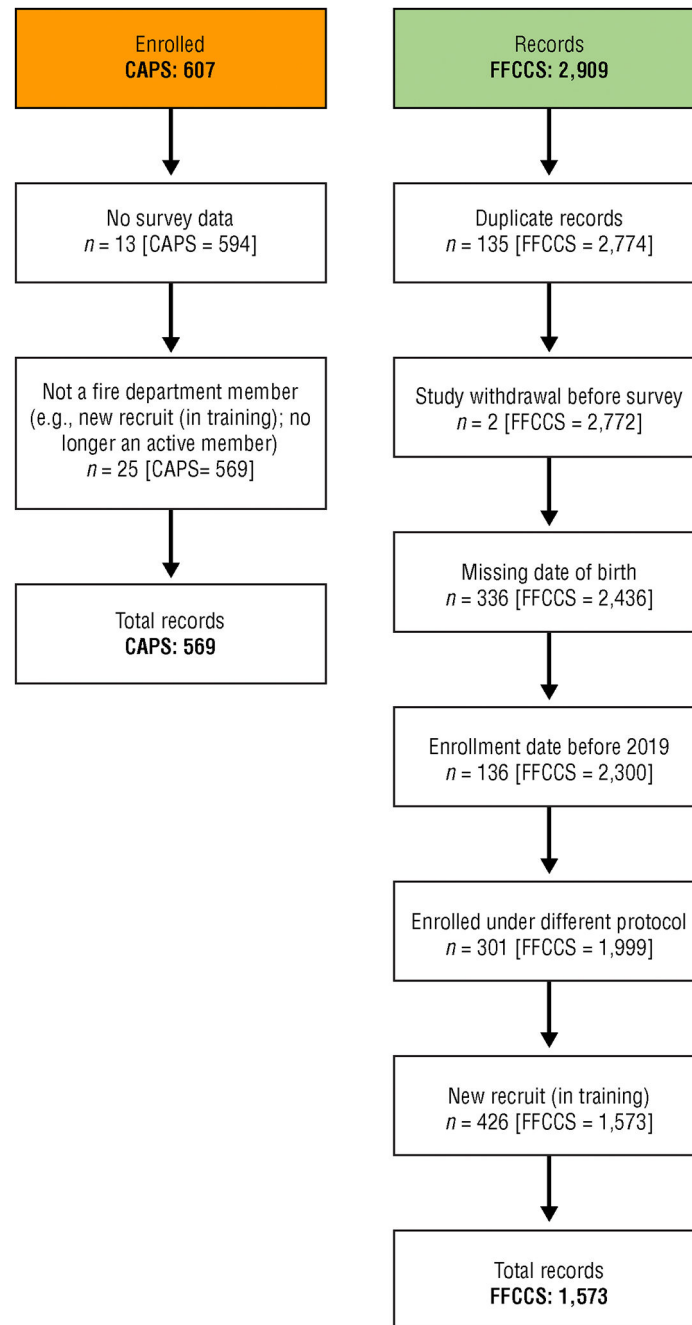


Figure 2.
Firefighter Cancer Assessment and Prevention Study (CAPS) and Fire Fighter Cancer Cohort Study (FFCCS) Enrollment and Study Data Records Selection; November 2019 to January 2023

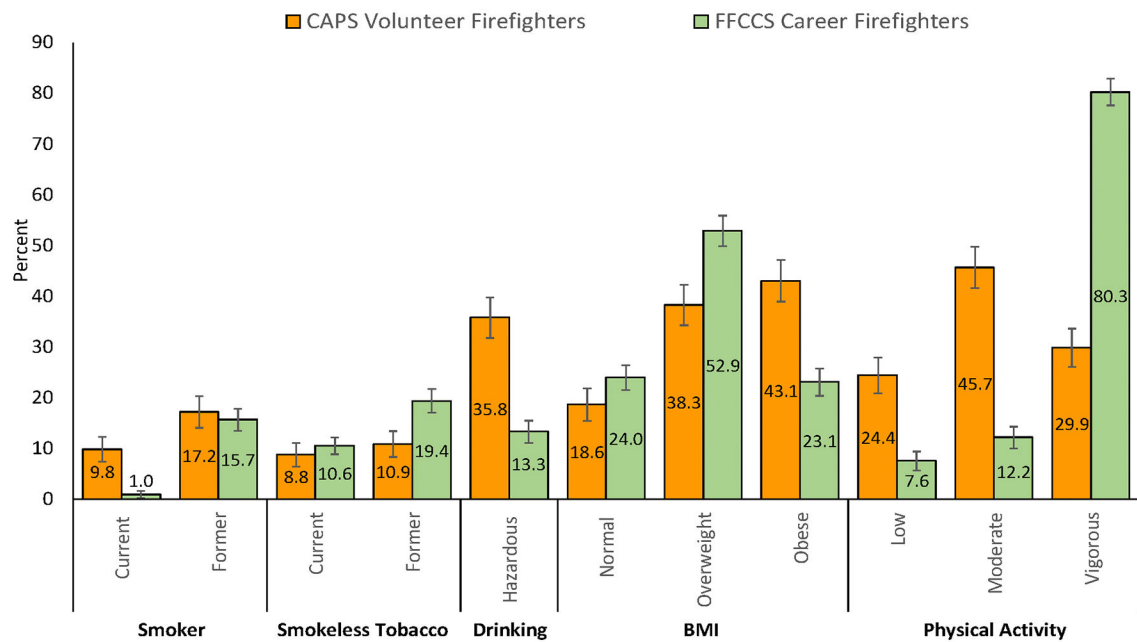


Figure 3. Cancer-Related Health Behavior Characteristics of CAPS Volunteer Firefighters (N = 569) and FFCCS Career Firefighters (N = 1,573)

Note. FFCCS career firefighter data weighted to the 2021 Current Population Survey (CPS) race-ethnicity, sex, and age distribution for firefighters 18 years or older. Smoking is defined as ever having smoked 100 cigarettes or more; former smokers no longer smoked any cigarettes; current smokers reported any level of smoking. Hazardous alcohol consumption: For males, having ≥ 14 drinks per week and for females, having ≥ 7 more drinks per week. BMI calculated using $\text{weight (lb)}/[\text{height (in.)}]^2 \times [703 (\text{kg}/\text{m}^2)/(\text{lb}/\text{in.}^2)]$. Physical activity rating categories were based on an 8-point past 30-day physical activity self-rating (0–1: inactive/low; 2–4: moderate; 4–7: vigorous).

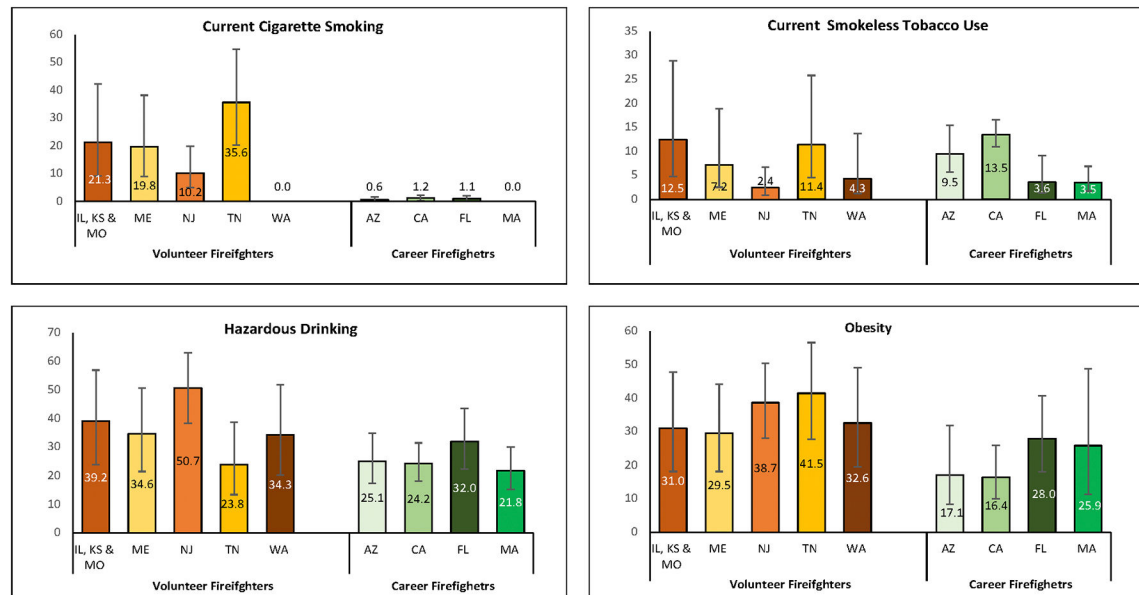


Figure 4.

Prevalence of Cancer-Related Health Behaviors for Volunteer Firefighters (N = 475) and Career Firefighters (N = 1,551) 18 to 60 Years Old, by State; Estimated Using Generalized Linear Multivariable Models Adjusted for Age, Sex, Race-Ethnicity, and Fire Department (as a Random Effect)

Note. State abbreviation and number (*n*) of enrolled firefighters: Illinois, Kansas, and Missouri (IL, KS & MO, *n* = 57); Maine (ME, *n* = 86); New Jersey (NJ, *n* = 236); Tennessee (TN, *n* = 78); Washington (WA, *n* = 50); Arizona (AZ, *n* = 163); California (CA, *n* = 818); Florida (FL, *n* = 151); and Massachusetts (MA, *n* = 182). This analysis was restricted to firefighters under age 60 and younger. Generalized mixed-effects logistic model, adjusted for age, sex, race-ethnicity, state (fixed effect), and fire department (random effect).

Table 1

Demographic, Firefighting, and Health Behavior Characteristics of CAPS Volunteer Firefighters and FFCCS Career Firefighters

	CAPS Volunteer Firefighters (N = 569)			FFCCS Career Firefighters ^a (N = 1,573)		
	<i>n</i>	Median	(IQR) ^b	<i>n</i>	Median	(IQR) ^b
Monthly FD call responses ^c	567	10.0	(5.0, 20.0)	1,212	50.0	(20.0, 112.0)
Firefighting experience (years) ^d	569	14.0	(5.0, 30.0)	1,550	12.0	(4.0, 21.0)
Age	569	42.5	(30.6, 56.4)	1,573	39.5	(31.8, 49.0)
	<i>n</i>	%	95% CI ^b	<i>n</i>	%	95% CI ^b
Current firefighting rank						
Firefighter	368	64.7	(60.7, 68.6)	1,116	64.8	(61.7, 67.8)
Company officer	125	22.0	(18.6, 25.4)	349	28.1	(25.2, 30.9)
Chief officer	76	13.4	(10.6, 16.2)	74	7.2	(5.4, 9.0)
Population of community served						
< 10,000	227	39.9	(35.9, 43.9)	7	0.3	(0.0, 0.6)
10,000 to 24,999	127	22.3	(18.9, 25.8)	–	–	–
25,000 to 99,999	215	37.8	(33.8, 41.8)	92	6.8	(5.2, 8.5)
100,000 to 999,999	–	–	–	509	36.2	(33.3, 39.1)
≥ 1,000,000	–	–	–	954	56.6	(53.6, 59.6)
Male	511	89.8	(87.3, 92.3)	1,475	96.3	(95.4, 97.3)
Non-Hispanic White	517	90.9	(88.5, 93.2)	967	78.6	(76.0, 81.1)
Marital status						
Married or partnered	367	64.5	(60.6, 68.4)	1,026	70.7	(68.0, 73.3)
Separated/divorced/widowed	50	8.8	(6.5, 11.1)	114	8.3	(6.6, 10.1)
Never married	152	26.7	(23.1, 30.4)	429	21.0	(18.7, 23.3)
Education level						
High school or lower	141	24.8	(21.3, 28.4)	143	8.5	(6.9, 10.2)
Some college	237	41.7	(37.7, 45.8)	935	58.4	(55.5, 61.4)
College or more	190	33.5	(29.6, 37.3)	490	33.0	(30.2, 35.8)
Household Income, > \$75,000	333	61.9	(57.8, 66.0)	835	91.3	(89.2, 93.3)
Current employment status						
Unemployed	92	16.2	(13.1, 19.2)	–	–	–
Part-time	31	5.4	(3.6, 7.3)	–	–	–
Full-time	364	64.0	(60.0, 67.9)	1,573	100.0	–
> Full-time	82	14.4	(11.5, 17.3)	158	11.1	(9.1, 13.1)

^aFFCCS career firefighter data weighted to the 2021 Current Population Survey race-ethnicity, sex, and age distribution for firefighters 18 years or older.

^bIQR = Interquartile range; 95% CI = 95% confidence interval.

^cThe average number of monthly fire department (FD) calls responded to by career firefighters was calculated based on participant-reported shift schedules. The shift schedule type was used to estimate shifts per month, which were then multiplied by the calls responded to per shift.

^dIncludes both career and volunteer experience, accounting for any gaps in service.

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Table 2

Demographic, Firefighting, and Health Care Access of CAPS Volunteer Firefighters (N = 569)

	Illinois, Missouri, & Kansas (5 FDs; 57 FFs) ^a Median (IQR) ^b	Maine (3 FDs; 1 County; 86 FFs) ^a Median (IQR) ^b	Maryland (2 FDs; 33 FFs) ^a Median (IQR) ^b	New Jersey (14 FDs; 236 FFs) ^a Median (IQR) ^b	Tennessee (10 FDs; 78 FFs) ^a Median (IQR) ^b	Washington (4 FDs; 50 FFs) ^a Median (IQR) ^b
Years of service	10.0 (3.0, 21.0)	17.0 (5.0, 36.0)	14.0 (6.0, 25.0)	20.0 (8.0, 34.5)	8.5 (2.0, 20.0)	9.0 (1.0, 20.0)
Monthly FD call responses	10.0 (3.0, 20.0)	10.0 (4.0, 20.0)	20.0 (10.0, 30.0)	15.0 (10.0, 20.0)	5.0 (2.0, 10.0)	25.0 (6.0, 60.0)
Age	34.8 (25.9, 54.2)	45.9 (33.6, 57.2)	44.8 (28.5, 54.7)	46.7 (33.1, 58.9)	39.0 (28.9, 51.4)	33.8 (24.5, 44.2)
	% (95% CI) ^c	% (95% CI) ^c	% (95% CI) ^c	% (95% CI) ^c	% (95% CI) ^c	% (95% CI) ^c
Non-Hispanic White	98.2 (94.7, 100)	98.8 (96.5, 100)	87.9 (76.1, 99.6)	87.7 (83.5, 91.9)	92.3 (86.3, 98.4)	80.0 (68.5, 91.5)
Male	77.2 (66.0, 88.4)	87.2 (80.0, 94.4)	84.8 (71.9, 97.8)	95.8 (93.2, 98.4)	89.7 (82.9, 96.6)	86.0 (76.0, 96.0)
Has health insurance	98.2 (94.7, 100)	94.2 (89.1, 99.2)	100 (100, 100)	96.6 (94.3, 98.9)	78.2 (68.8, 87.6)	86.0 (76.0, 96.0)
Has a primary care provider	80.7 (70.1, 91.3)	89.5 (82.9, 96.1)	93.9 (85.3, 100)	79.7 (74.5, 84.8)	74.4 (64.5, 84.3)	74.0 (61.4, 86.6)

^aFDs= Fire departments; FF= Firefighters.^bIQR = Interquartile range.^c95% CI = 95% confidence interval.