


## RESEARCH ARTICLE

# Prevalence and predictors of colon and prostate cancer screening among volunteer firefighters: The United States Firefighter Cancer Assessment and Prevention Study

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## Abstract

**Background:** Although firefighters have increased risk for colon and prostate cancer, limited information exists on screening practices for these cancers in volunteer firefighters who compose two-thirds of the US fire service. We estimated the prevalence of colon and prostate cancer screening among volunteer firefighters using eligibility criteria from 4 evidence-based screening recommendations and evaluated factors influencing screening.

**Methods:** We evaluated colon ( $n = 569$ ) and prostate ( $n = 498$ ) cancer screening prevalence in a sample of US volunteer firefighters using eligibility criteria from the US Preventive Services Taskforce (USPSTF), National Fire Protection Association, American Cancer Society, and National Comprehensive Cancer Network. We assessed associations with fire service experience, demographics, and cancer risk perception based on USPSTF guidelines.

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**Results:** For those eligible based on USPSTF guidelines, colon and prostate cancer screening prevalence was 51.7% (95% CI: 45.7, 57.8) and 48.8% (95% CI: 40.0, 57.6), respectively. Higher odds of colon and prostate cancer screening were observed with older age and with some college education compared to those with less education. Fire service experience and cancer risk perception were not associated with screening practices.

**Conclusion:** This is the first large study to assess colon and prostate cancer screening among US volunteer firefighters based on different screening guidelines. Our findings suggest gaps in cancer prevention efforts in the US volunteer fire service. Promoting cancer screening education and opportunities for volunteer firefighters by their fire departments, healthcare professionals, and public health practitioners, may help to address the gaps.

#### KEYWORDS

cancer screening, colon cancer, firefighters, occupational cancer prevention and control, prostate cancer

## 1 | INTRODUCTION

Through their work, firefighters can be exposed to many known and suspected human carcinogens such as diesel exhaust, heavy metals, and polyhalogenated or polycyclic aromatic hydrocarbons.<sup>1</sup> In 2022, the International Agency for Research on Cancer (IARC) reclassified the occupation as a firefighter as “carcinogenic to humans” (Group 1) from its 2010 classification of “possibly carcinogenic to humans” (Group 2B),<sup>1</sup> in part based on epidemiological evidence of positive associations between occupation as a firefighter and increased risk for specific cancer sites, including the colon and prostate.<sup>2</sup> Screening is essential for early detection and control of colon and prostate cancer. However, limited knowledge exists on cancer screening adoption and influencing factors among firefighters, particularly volunteer firefighters, an under-researched majority, who make up nearly two-thirds (65%) of the US fire service.<sup>3</sup>

While volunteer firefighters have similar firefighting duties as their career counterparts, they generally spend less time in their fire stations, have full-time jobs, and face challenges in balancing their firefighting responsibilities with work and family obligations.<sup>4,5</sup> These factors can act as barriers to receiving routine cancer screening. Additionally, volunteer firefighters generally have limited access to routine occupational health monitoring, including cancer screening, and limited resources through their fire departments, such as cancer prevention programs or education.<sup>3,6</sup> Moreover, they typically have limited access to on-site facilities both for laundering gear and for practicing postexposure reduction after a fire response, contributing to unmitigated exposure risk.<sup>6</sup>

The US Preventive Services Task Force (USPSTF), a nonprofit organization whose evidence-based recommendations impact insurance coverage of prevention services, strongly recommends colon cancer screening through direct visualization (e.g., colonoscopy) or stool-based tests for people aged 45–75 years and selective screening for those aged

76–85 years.<sup>7</sup> The National Fire Protection Association (NFPA), a nonprofit organization that develops firefighter health and safety standards, recommends the same screening tests for firefighters aged 45–75 years in their Standard on Comprehensive Occupational Medical Program for Fire Departments (NFPA 1582).<sup>8</sup> There are no specific NFPA recommendations for those aged 76–85.

For prostate cancer screening among the general population, USPSTF recommends selective prostate-specific antigen (PSA) testing for those aged 55–69 years after discussing the potential benefits and harms of the test with their clinician.<sup>9</sup> The NFPA recommends that firefighters discuss annual PSA testing with a clinician when they are 50 years or older. For firefighters who are African American or who have a family history of prostate cancer, the NFPA recommends that annual screening begin at 40 years or older based on discussions with a clinician.<sup>8</sup>

There is a small but growing body of literature on cancer screening in career firefighters which can be relevant in understanding screening adoption among volunteer firefighters. A cross-sectional study reported that among the 127 Florida career departments surveyed, 44% provided some type of cancer screening for their members in the past year.<sup>10</sup> Another study of 3152 Florida career firefighters found that 33.5% had PSA testing and 29.9% had a colonoscopy in their lifetime; however, evidence-based eligibility criteria and other colon cancer screening methods were not assessed.<sup>11</sup> Among both volunteer and career firefighters, cancer screening may be influenced by the perceived increased risk of cancer from firefighting. A cross-sectional study of 167 US career and volunteer firefighters found that firefighters reported a high perceived risk of colon and prostate cancer (rated 4 out of 5 on a Likert scale).<sup>12</sup> A qualitative study reported that although firefighters had a fatalistic view toward their cancer risk from firefighting, they expressed cancer screening could mitigate their cancer risk.<sup>13</sup>

Research is needed to guide cancer prevention and control programs among volunteer firefighters. This study investigates the prevalence of

colon and prostate cancer screening among a sample of US volunteer firefighters, based on USPSTF and NFPA screening recommendations. Additionally, the study examines the association between demographic, fire service experience, and cancer risk perception characteristics and screening for colon and prostate cancer among these volunteer firefighters.

## 2 | MATERIALS AND METHODS

### 2.1 | Study design and survey instrument

This cross-sectional study examines cancer screening among volunteer firefighters in the Firefighter Cancer Assessment and Prevention Study (CAPS). CAPS aims to identify risk factors associated with cancer risk in this population. Incumbent volunteer firefighters aged 18 years or older from 41 US departments (majority volunteer and 8 combination) in 9 states (Connecticut, Illinois, Kansas, Maine, Maryland, Missouri, New Jersey, Tennessee, and Washington) across the continental US were consented and enrolled in CAPS from July 2019 to January 2023 using convenience sampling. Fire department membership ranged in size from less than 10 to over 250 members.

CAPS participants completed a comprehensive enrollment survey that collected information on demographics, fire service experience, healthcare access, employment history, cancer history, screening practices, and health behaviors. The survey was conducted online using REDCap, a secure survey management system.<sup>14</sup> The survey questions were adapted from the Fire Fighter Cancer Cohort Study (FFCCS) enrollment survey,<sup>15</sup> with modifications specific to volunteer firefighters.<sup>16–18</sup> The study was approved by the University of Arizona Institutional Review Board.

### 2.2 | Cancer screening definition and selection criteria

The CAPS enrollment survey included questions on screening history for colon and prostate cancer. For colon cancer screening, participants were asked if they ever received a colonoscopy, sigmoidoscopy, or stool-based test (performed at home); the last year of each test; and the primary reason for the test. For prostate cancer screening, male firefighters were asked if they ever received a PSA test, the reason they received the test, and the last year of the test.

Cancer screening prevalence was calculated based on the most recent screening recommendations that were in place at the time of the study period from USPSTF and NFPA.<sup>8,9,19</sup> Since firefighters could have received cancer screening based on other general population screening guidelines, we also assessed screening based on recommendations from the American Cancer Society (ACS)<sup>20</sup> and the National Comprehensive Cancer Network (NCCN).<sup>21,22</sup> NCCN includes occupational risk factors in their evidence assessment. The cancer screening criteria for each cancer by each organization is summarized in Table 1.

To be considered as screened, for each cancer, CAPS volunteer firefighters must have received the test as a part of a routine exam or as a follow-up test from an earlier test/screening, within the appropriate time frame, and be eligible based on family history or race/ethnicity characteristics, based on the relevant guideline (USPSTF, NFPA, ACS, or NCCN). For colon cancer screening, this included receiving at least one of the three tests in the appropriate time as a part of routine screening: colonoscopy within the last 10 years, sigmoidoscopy within the last 5 years, and stool-based test within the past year. Participants who did not report receiving a test, were unsure, or reported receiving a test for reasons other than routine screening, were considered to not be screened. We excluded participants who reported a history of prostate or colon cancer from the relevant analysis; additionally, we excluded participants who reported a history of rectal cancer from the colon cancer screening analysis. We assessed colon cancer screening among both male and female volunteer firefighters.

We assessed the predictors of colon and prostate cancer screening among firefighters who were eligible based on USPSTF guidelines because these recommendations impact insurance coverage for cancer screening. In addition, NFPA screening guidelines use USPSTF evidence as a source for the firefighter-specific recommendations.<sup>8</sup>

Given that participants may have been screened for colon and prostate cancer outside of the guidelines set by USPSTF, NFPA, ACS, and NCCN, or that they may have received screening based on a previous guideline, we evaluated age, family cancer history, race/ethnicity, and cancer risk perception among participants who were screened.

### 2.3 | Study measures

The primary firefighter characteristics assessed were: years of fire service (including volunteer and career service, accounting for any overlap between the two); the average number of monthly firefighting calls responded to ( $\leq 5$ , 6–10, 11–20, and  $>20$  calls); and the longest held department rank combined into firefighter (including those who also had paramedic roles, and driver operators), chief (including battalion, deputy, fire, paramedic, or other chief), or other leadership (including inspector, fire investigator, lieutenant, or captain).

We also explored demographic characteristics, employment history, and cancer risk perception. Demographic characteristics included age, educational attainment (high school graduate, some college or Associate degree, and 4-year college degree or more), and race and ethnicity (Non-Hispanic white, Non-Hispanic black, or other). We included employment history as the longest-held primary occupation, categorized as: construction or manufacturing, government or clerical, service provider, or other. Perceived cancer risk was measured by asking, "Compared to a man/woman your age who has never been a firefighter, would you say that you are more likely to get cancer, less likely, or about as likely?" We categorized this as higher, similar, or lower perceived risk. Healthcare access characteristics we included were health insurance coverage, having a primary care physician, and visiting a physician within the year preceding the survey.

**TABLE 1** Cancer screening eligibility criteria, recommended test and frequency for colon and prostate cancer based on guidelines from the United States Preventive Services Taskforce (USPSTF), National Fire Protection Association (NFPA), American Cancer Society (ACS), and National Comprehensive Cancer Network (NCCN).

Screening Guidelines	Eligibility criteria	Screening test and frequency
<b>Colon cancer</b>		
USPSTF	Male and female, 45–85 years <sup>a</sup>	Colonoscopy every 10 years, CT colonography every 5 years, sigmoidoscopy every 5 years, sigmoidoscopy every 10 years with FIT every year, FOBT or FIT annually, or sDNA-FIT every 1 to 3 years
NFPA	Male and female, 45–75 years	Colonoscopy every 10 years, CT colonography every 5 years, sigmoidoscopy every 5 years, FOBT or FIT annually, or sDNA-FIT every 1 to 3 years
ACS	Male and female, 45–85 years <sup>a</sup>	Colonoscopy every 10 years, CT colonography every 5 years, sigmoidoscopy every 5 years, FOBT or FIT annually, or sDNA-FIT every 3 years
NCCN	Male and female, 50–85 years <sup>a</sup>	Colonoscopy every 10 years, CT colonography every 5 years, sigmoidoscopy every 5 years, FOBT or FIT annually, or sDNA-FIT every 3 years
<b>Prostate cancer</b>		
USPSTF	Male, 55–69 years <sup>b</sup>	Selective PSA testing based on discussion with healthcare provider is encouraged
NFPA	Male, ≥50 years (≥40 years for African Americans and those with first-degree family member history)	PSA testing annually based on discussion with healthcare provider is encouraged
ACS	Male, 50–75 years (45–75 years for African Americans and 40–75 years for those with first-degree family member history)	Selective PSA testing based on discussion with healthcare provider is encouraged
NCCN	Male, 45–75 years	PSA testing varies by patient based on baseline PSA testing

Abbreviations: ACS, American Cancer Society; CT, computed tomography; FIT, fecal immunochemical test; FOBT, fecal occult blood test; NFPA, National Fire Protection Association; NCCN, National Comprehensive Cancer Network; PSA, prostate-specific antigen; sDNA-FIT, stool DNA test with fecal immunochemical test; USPSTF, United States Preventive Services Task Force.

CT colonography was not asked in the CAPS survey. Home-based stool tests (FIT, FOBT, and sDNA-FIT) reported within the past 12 months only.

<sup>a</sup>Selective screening recommended among those 76–85 years based on patient preference.

<sup>b</sup>Selective PSA-based screening recommended among all individuals, as well the USPSTF recommends against PSA-based screening for males ≥70 years.

## 2.4 | Statistical analysis

### 2.4.1 | Cancer screening eligibility and prevalence

To describe demographic, fire service experience, and cancer risk perception characteristics among all CAPS volunteer firefighters (colon cancer screening) and among male firefighters (prostate cancer screening), we calculated frequency, percent frequency, and 95% confidence intervals (CIs). After determining cancer screening eligibility described in Table 1, we estimated the prevalence and 95% CIs of colon and prostate cancer screening based on each of recommendations from USPSTF, NFPA, ACS, and NCCN.

### 2.4.2 | Predictors of cancer screening

We examined cancer screening among eligible volunteer firefighters based on USPSTF guidelines. We assessed screening by demographics, experience, employment history, and cancer risk perception. Multivariable

logistic regression was used to analyze associations, calculating adjusted odds ratios and 95% CIs for colon and prostate cancer screening. The analyses were exploratory, and variables were selected for inclusion based on a priori decision to assess characteristics that can influence screening as well as reduce potential confounding effects. Linearity of log odds with continuous variables was inspected through visual inspection and Box-Tidwell transformation.<sup>23</sup> Age and years of firefighting service were included as continuous variables, while monthly firefighting calls was categorical. Education, fire department rank, and cancer risk perception were recategorized as binary variables for increased statistical power. SAS (version 9.4) statistical software was used for all analyses.

## 3 | RESULTS

Of the 569 incumbent volunteer firefighters enrolled in CAPS, none were excluded from the screening analysis based on their reported history of colon or rectal cancer. Among the 511 male firefighters, 13 firefighters were excluded from the prostate cancer screening

assessment due to a reported history of prostate cancer, resulting in a final sample of 498 firefighters. Most participants (83.8%) were enrolled during or after 2021, with 45.5% of these participants being enrolled specifically in 2022.

CAPS participants were predominantly Non-Hispanic white (91.0%) and males (89.8%). They had an average age of 43.3 years (range: 18 to 82 years) and an average firefighting experience of 18.2 years (range: <1 to 60 years). Most had health insurance (87.2%) with 27.6% of the insured firefighters reporting obtaining insurance from the fire service or government programs. Two-thirds of CAPS volunteer firefighters perceived they had higher cancer risk compared to non-firefighter adults. Participant characteristics were similar between CAPS firefighters assessed for colon cancer screening and those assessed for prostate cancer screening. (Table 2).

### 3.1 | Prevalence of cancer screening

Of the 46.2% ( $n = 263$ ) of the CAPS volunteer firefighters eligible for colon cancer screening based on USPSTF and ACS guidelines, just over half (51.7%) were screened (Table 3). USPSTF recommends selective screening among those aged 76 to 85 years. There were 4 firefighters in this age group who were all screened. Similarly, based on NFPA guidelines, of the 45.5% ( $n = 259$ ) eligible, 51.0% received screening. The prevalence of screening was highest according to NCCN guidelines (62.3%); however, the proportion of eligible participants was lower (36.4%,  $n = 207$ ). Among those eligible according to any guideline, 7.4% reported receiving more than one test. Colonoscopy was the most common screening test (96.3%), followed by stool-based tests (18.4%), while sigmoidoscopy was rarely reported (<5%).

Of the 25.1% ( $n = 125$ ) of male volunteer firefighters eligible for prostate cancer screening based on USPSTF guidelines, less than half (48.8%) were screened (Table 3). Although the prevalence of prostate screening was the highest according to USPSTF guidelines, the proportion eligible was the lowest. The prevalence of screening could not be estimated for about a third of NFPA-eligible firefighters (37.6%,  $n = 187$ ) due to missing data on the last year of PSA tests for 29.3% of ever-screened respondents. However, among NFPA-eligible firefighters with available data, 78.3% received a PSA-test within the year of their survey date. None of the eligible participants, based on any guideline, were identified as Black or African American.

### 3.2 | Predictors of cancer screening

Among the volunteer firefighters who were eligible for colon cancer screening based on USPSTF guidelines, compared to those who were not screened, screened individuals were on average older (61.2 years [60.0, 62.4] vs. 53.5 years [52.3, 54.7], respectively), and had more years of firefighting (32.8 years [30.3, 35.3] vs. 25.8 years [23.6, 28.0], respectively) (Table 4). Average age and years of firefighting were similar between those screened and not screened for prostate

cancer. For the colon cancer screening multivariable analysis, the sample size was 261 firefighters after excluding two participants who were missing values for monthly firefighting calls. The odds of receiving colon or prostate cancer screening increased with age (Table 5). The odds of receiving colon or prostate cancer screening were over twice as high among those with some college education compared to those with a high school education or less (OR: 2.09 [1.05, 4.15] and OR: 2.90 [1.15, 7.34], respectively).

### 3.3 | Cancer screening outside recommendations

There were 8 firefighters who were screened for colon cancer outside of current USPSTF, NFPA, ACS, or NCCN guidelines (age range: 24 to 43 years). Only one participant had a family history of colon cancer and six firefighters perceived themselves to have high cancer risk. Seven participants were non-Hispanic white.

Only 10 firefighters reported ever being screened for prostate cancer outside of any screening guidelines (age range: 32 to 44 years); 8 had a high perceived risk of cancer. Reviewing these participants for prostate cancer risk factors two had a family history and none were Black or African American.

## 4 | DISCUSSION

To our knowledge, this is the first study in the US to examine colon and prostate cancer screening prevalence and predictors among volunteer firefighters which also considered multiple screening guidelines (USPSTF, NFPA, ACS, and NCCN). Among those who were eligible based on any recommendation, just over half of the firefighters were screened for colon cancer, while less than half were screened for prostate cancer. Age and education were strong predictors of screening for both cancers, while fire service history was not associated with either cancer. Although a majority of firefighters perceived themselves as having higher cancer risk, it was not associated with screening for either cancer site.

Compared to studies in the general population, volunteer firefighters in our study had a lower prevalence of colon cancer screening based on USPSTF, NFPA, and ACS guidelines. An ACS analysis of colon cancer screening among US adults aged  $\geq 45$  years using 2021 National Health Interview Survey data reported that 59% were up to date on their screening.<sup>24</sup> It is important to note that CAPS firefighters were predominately white and male. According to the ACS analysis, 61% of white adults and 58% of males were up to date with their screening.<sup>24</sup> The ACS screening prevalence estimate was similar (58%) for those aged 45–75 years, the same age-range for eligibility recommended by NFPA. Among these US adults, 60% of white adults and 56% of males were up to date with their screening.<sup>24</sup>

Stool-based tests can be completed at home and do not require attending screening examinations.<sup>7</sup> Stool-based tests were reported by a small proportion of firefighters as colonoscopy was the most common screening, similar to that observed in the US general population.<sup>24</sup> However, a study conducted on active and retired

**TABLE 2** Characteristics of volunteer firefighters enrolled in the Firefighter Cancer Assessment and Prevention Study (CAPS) (*n* = 569).

Characteristics	All CAPS volunteer firefighters ( <i>n</i> = 569)		Male CAPS volunteer firefighters* ( <i>n</i> = 498)	
	<i>n</i> (%)	95% CI	<i>n</i> (%)	95% CI
<b>Age</b>				
18–34 years	205 (36.0)	(32.1, 40.0)	172 (34.5)	(30.3, 38.7)
35–49 years	157 (27.6)	(23.9, 31.3)	141 (28.3)	(24.3, 32.3)
≥50 years	207 (36.4)	(32.4, 40.3)	185 (37.1)	(32.9, 41.4)
<b>Sex, male</b>	511 (89.8)	(87.3, 92.3)	498 (100)	–
<b>Race/Ethnicity</b>				
Non-Hispanic white	517 (91.0)	(88.7, 93.4)	451 (90.6)	(88, 93.1)
Non-Hispanic black	11 (1.9)	(0.8, 3.1)	11 (2.2)	(0.9, 3.5)
Other	41 (7.2)	(5.1, 9.3)	36 (7.2)	(4.9, 9.5)
<b>Education</b>				
High school graduate or GED or lower	141 (24.8)	(21.3, 28.4)	131 (26.4)	(22.5, 30.2)
Some college, technical school, or associate degree	237 (41.7)	(37.7, 45.8)	205 (41.2)	(36.9, 45.6)
College graduate or higher	190 (33.5)	(29.6, 37.3)	161 (32.4)	(28.3, 36.5)
<b>Annual household income, ≥\$75,000</b>	333 (61.9)	(57.8, 66.0)	296 (62.8)	(58.5, 67.2)
<b>Marital status, married or partnered</b>	367 (64.5)	(60.6, 68.4)	325 (65.3)	(61.1, 69.5)
<b>Health insurance</b>				
Through fire service or local/state government	157 (27.6)	(23.9, 31.3)	140 (28.1)	(24.2, 32.1)
Through employer, workplace, or union	274 (48.2)	(44, 52.3)	242 (48.6)	(44.2, 53)
Through direct purchase or spouse	65 (11.4)	(8.8, 14.0)	55 (11.0)	(8.3, 13.8)
None or not sure	73 (12.8)	(10.1, 15.6)	61 (12.2)	(9.4, 15.1)
<b>Has a primary healthcare provider</b>	463 (81.4)	(78.2, 84.6)	403 (80.9)	(77.5, 84.4)
<b>Visited a healthcare provider in the past 12 months</b>	511 (89.8)	(87.3, 92.3)	441 (88.6)	(85.7, 91.4)
<b>Ever worked as a career firefighter</b>				
<b>Years of firefighting service<sup>a</sup></b>				
≤10 years	218 (38.3)	(34.3, 42.3)	180 (36.1)	(31.9, 40.4)
11–29 years	208 (36.6)	(32.6, 40.5)	187 (37.6)	(33.3, 41.8)
≥30 years	143 (25.1)	(21.6, 28.7)	131 (26.3)	(22.4, 30.2)
<b>Monthly firefighting calls</b>				
≤5	161 (28.4)	(24.7, 32.1)	133 (26.8)	(22.9, 30.7)
6–10	128 (22.6)	(19.1, 26)	118 (23.7)	(20.0, 27.5)
11–20	157 (27.7)	(24.0, 31.4)	138 (27.8)	(23.8, 31.7)
>20	121 (21.3)	(18, 24.7)	108 (21.7)	(18.1, 25.4)
<b>Longest-held firefighting rank</b>				
Firefighter	381 (67.0)	(63.1, 70.8)	323 (64.9)	(60.7, 69.1)
Chief or company officer	111 (19.5)	(16.2, 22.8)	101 (20.3)	(16.7, 23.8)
Other leadership	77 (13.5)	(10.7, 16.4)	74 (14.9)	(11.7, 18.0)



TABLE 2 (Continued)

Characteristics	All CAPS volunteer firefighters (n = 569)		Male CAPS volunteer firefighters* (n = 498)	
	n (%)	95% CI	n (%)	95% CI
<b>Longest held occupation</b>				
Construction or manufacturing	162 (28.5)	(24.8, 32.2)	154 (30.9)	(26.9, 35.0)
Government or clerical	175 (30.8)	(27.0, 34.6)	146 (29.3)	(25.3, 33.3)
Service provider	160 (28.1)	(24.4, 31.8)	136 (27.3)	(23.4, 31.2)
Other	72 (12.7)	(9.9, 15.4)	62 (12.4)	(9.5, 15.4)
<b>All cancer risk perception<sup>b</sup></b>				
Higher perceived risk	355 (62.4)	(58.4, 66.4)	313 (62.9)	(58.6, 67.1)
Similar or lower perceived risk	214 (37.6)	(33.6, 41.6)	185 (37.1)	(32.9, 41.4)
<b>Parental history of colon or rectal cancer<sup>c</sup></b>				
	34 (6.0)	(4.0, 7.9)	–	–
<b>Father or brother(s) had history of prostate cancer<sup>c</sup></b>				
	–		34 (6.8)	(4.6, 9.1)

Abbreviation: CAPS, Firefighter Cancer Assessment and Prevention Study.

Cell values may not add to the total sample size due to missing data.

\*Male CAPS volunteer firefighters with no history of prostate cancer.

<sup>a</sup>Accounts for both volunteer and career firefighting experience, and their possible overlap.

<sup>b</sup>All cancer risk perception compared to adult non-firefighters of same age.

<sup>c</sup>Biological family members only.

career firefighters in San Francisco ( $n = 498$ ) showed that when presented with a stool-based test program, 80.3% of participants completed the test.<sup>25</sup> These findings suggest that firefighters have the potential to adopt and use stool-based tests if given the opportunity. Stool-based tests could therefore be an especially useful colon cancer screening test for volunteer firefighters.

Based on the 2019 National Cancer Institute report, 39.0% of US male adults (55–69 years) received a PSA test within the past year for prostate cancer screening.<sup>26</sup> Among CAPS firefighters, the prevalence of ever receiving a PSA test based on USPSTF guidelines was 48.8%. For these firefighters, the prevalence estimate for receiving a PSA test in the past year would be the same or less than the ever-screened prevalence. While there is ongoing debate about the reliability of PSA testing, currently it is a selective screening test following discussions with a clinician, recommended by the USPSTF and the only option for prostate cancer screening among firefighters based on the NFPA recommendation.<sup>8,9</sup>

Eligibility criteria for screening varied across the four guidelines we examined. The CAPS data collection occurred between September 2019 and January 2023, during which USPSTF, NFPA, and NCCN updated their recommendations for colon cancer screenings. Changes in guidelines can affect the estimated prevalence. We used the most recent recommendations for all screening guidelines, which expanded eligibility criteria or added specificity based on available evidence. For instance, colon cancer screening guidelines were updated from 50 to 85 years to 45–85 years by USPSTF and NCCN.<sup>7,22</sup> Therefore, the reported screening prevalence in this study

may be marginally underestimated. Prostate cancer screening recommendations remained the same through the study period.

Fire service history and cancer risk perception were not associated with cancer screening among CAPS volunteer firefighters. However, there may be other unexplored factors that could influence screening, such as fire department provision of medical monitoring. According to the most recent NFPA needs assessment, approximately 38% of career or mostly career fire departments, which generally serve large urban communities, had cancer screening programs. In contrast, only 10% of volunteer and mostly volunteer fire departments (such as CAPS departments), which tend to serve smaller suburban or rural communities, reported having a cancer screening program in place. Volunteer and mostly volunteer departments also faced challenges in providing NFPA 1582-compliant medical evaluations,<sup>8</sup> including colon and prostate cancer screenings. Approximately 58% of departments reported not offering such evaluations, compared to about 22% for career or mostly career combination departments.<sup>6</sup> Cancer screening prevalence may also vary based on the region a fire department is located in such that departments in areas with higher cancer incidence may have higher screening prevalence. Between 2016 and 2020, among non-Hispanic white males, in the states where CAPS enrollment occurred, age-adjusted colon cancer incidence rates were the lowest in Washington and Connecticut, and the highest in Illinois. Prostate cancer incidence rates were lowest in Missouri and the highest in New Jersey.<sup>27</sup> These findings indicate potential geographic variation in screening practices among volunteer firefighters and departments.

**TABLE 3** Prevalence of colon and prostate (male only) cancer screening among the volunteer firefighters enrolled in the Firefighter Cancer Assessment and Prevention Study (CAPS) by organization.

	Colon cancer (n = 569)		Prostate cancer (n = 498)	
	n (%)	95% CI	n (%)	95% CI
<b>Eligible for cancer screening</b>				
USPSTF	263 (46.2)	(42.1, 50.3)	125 (25.1)	(21.3, 28.9)
NFPA	259 (45.5)	(41.4, 49.6)	187 (37.6)	(33.3, 41.8)
ACS	263 (46.2)	(42.1, 50.3)	184 (36.9)	(32.7, 41.2)
NCCN	207 (36.4)	(32.4, 40.3)	233 (46.8)	(42.4, 51.2)
<b>Screened for cancer among eligible</b>				
USPSTF	136 (51.7)	(45.7, 57.8)	61 (48.8)	(40.0, 57.6)
NFPA	132 (51.0)	(44.9, 57.1)	–	
ACS	136 (51.7)	(45.7, 57.8)	84 (45.7)	(38.4, 52.9)
NCCN	129 (62.3)	(55.7, 68.9)	86 (36.9)	(30.7, 43.1)

Abbreviations: ACS, American Cancer Society; CAPS, Firefighter Cancer Assessment and Prevention Study; NFPA, National Fire Protection Association; NCCN, National Comprehensive Cancer Network; USPSTF, United States Preventive Services Task Force.

Prevalence of prostate cancer screening based on NFPA guidelines is not reported due to significant missingness for year of the most recent prostate-specific antigen (PSA) test.

A study of Florida career departments found that having dedicated occupational health and safety staff, committees, or budgets was associated with more cancer screening activities, although this has not been assessed among volunteer fire departments.<sup>10</sup> Another unmeasured factor is whether firefighters discussed cancer screening with their healthcare provider. A qualitative study conducted among Floridian career firefighters, describing the facilitators and barriers to cancer screening, revealed that firefighters had to initiate a discussion with their providers about firefighter-specific occupational exposures.<sup>28</sup> For CAPS participants, we could not assess whether their healthcare providers knew about the volunteers' firefighting status and related carcinogenic exposures, which could affect the discussion over cancer screening and consequently their receipt of screening.

Our study had some limitations. First, we did not collect data on virtual colonoscopy (computed tomography (CT) colonography), a screening test recommended by USPSTF, ACS, and NCCN. Consequently, the colon cancer screening prevalence based on these guidelines may be underestimated. Second, we could not determine the year of the last PSA test, limiting our evaluation of screening prevalence based on NFPA guidelines. Third, there is a possibility of selection bias due to our sampling approach, specifically that fire departments with leadership and members who are more aware of health problems related to firefighting may be more likely to enroll than those less aware. As such these findings may overestimate cancer screening prevalence. Fourth, residual confounding may have been introduced as some variables were operationalized in a binary format for the multivariable analyses. Lastly, CAPS data collection occurred during and immediately after the coronavirus disease (COVID-19) pandemic (2019–2023), which may have affected access to cancer screening among the firefighters. Finally, while most CAPS

departments were volunteer, the impact of being an exclusive volunteer or combination department and the effect of related departmental resources could not be assessed in this study. However, the variation in cancer screening resources may be related to regional differences rather than volunteer or combination status of a department.

However, our study also had some notable strengths, including the sample size, geographic coverage, and representation from rural and suburban departments. We used screening guidelines from four prominent organizations, including specific guidelines tailored for firefighters (NFPA) and those impacting insurance coverage (USPSTF). Additionally, we explored firefighter characteristics and cancer risk perception which are important in addressing gaps in volunteer firefighters' early cancer detection and control.

In conclusion, our study provides important insights into the prevalence of cancer screening among volunteer firefighters and factors associated with screening. While there are well-established population-based screening guidelines for colon and prostate cancer, volunteer firefighters had lower colon cancer screening prevalence than comparable groups in the general population and less than half of the eligible firefighters were screened for prostate cancer, despite the elevated cancer risk among firefighters for these cancer sites. Cancer screening education and opportunities for volunteer firefighters may be promoted by their fire departments, healthcare professionals, and public health practitioners, to help address these gaps. Specifically, the leadership of volunteer fire departments may encourage their volunteers to discuss firefighting exposures and screening eligibility with their healthcare providers. Additionally, public health practitioners can work together with volunteer fire departments to assess their specific needs and gaps in cancer prevention. Incorporating prioritization of early detection and cancer



**TABLE 4** Characteristics of volunteer firefighters enrolled in the Firefighter Cancer Assessment and Prevention Study (CAPS) based on the United States Preventive Services Taskforce (USPTF) screening guidelines and eligibility for colon ( $n = 263$ ) and prostate ( $n = 125$ ) cancer.

Characteristics	Eligible for colon cancer screening ( $n = 263$ )			Received colon cancer screening ( $n = 136$ )			Did not receive colon cancer screening ( $n = 127$ )			Eligible for prostate cancer screening ( $n = 125$ )			Received prostate cancer screening ( $n = 61$ )			Did not receive prostate cancer screening ( $n = 64$ )		
	mean	95% CI	n (%)	mean	95% CI	n (%)	mean	95% CI	n (%)	mean	95% CI	n (%)	mean	95% CI	n (%)	mean	95% CI	n (%)
Age (years)	57.5	(56.5, 58.5)	61.2	(60.0, 62.4)	53.5	(52.3, 54.7)	61.1	(60.4, 61.8)	61.8	(60.8, 62.8)	60.5	(59.5, 61.4)						
Firefighting service (years) <sup>a</sup>	29.4	(27.7, 31.1)	32.8	(30.3, 35.3)	25.8	(23.6, 28.0)	34.3	(32.0, 36.5)	35.0	(31.6, 38.5)	33.5	(30.6, 36.5)						
<b>Sex, male</b>	249 (94.7)	(91.9, 97.4)	128 (94.1)	(90.1, 98.1)	121 (95.3)	(91.5, 99.0)	125 (100)	–	61 (100)	64 (100)								
<b>Race/Ethnicity, Non-Hispanic white<sup>b</sup></b>	250 (95.1)	(92.4, 97.7)	131 (96.3)	(93.1, 99.5)	119 (93.7)	(89.4, 98.0)	118 (94.4)	(90.3, 98.5)	58 (95.1)	(89.5, 100)	60 (93.8)	(87.7, 99.8)						
<b>Education</b>																		
Highschool graduate or GED or lower	65 (24.7)	(19.5, 30.0)	28 (20.6)	(13.7, 27.5)	37 (29.1)	(21.1, 37.1)	32 (25.6)	(17.8, 33.4)	10 (16.4)	(6.8, 26.0)	22 (34.4)	(22.4, 46.3)						
Some college, technical school, or associate degree	97 (36.9)	(31.0, 42.8)	53 (39.0)	(30.7, 47.3)	44 (34.6)	(26.3, 43.0)	53 (42.4)	(33.6, 51.2)	27 (44.3)	(31.4, 57.1)	26 (40.6)	(28.3, 53.0)						
College graduate or higher	101 (38.4)	(32.5, 44.3)	55 (40.4)	(32.1, 48.8)	46 (36.2)	(27.7, 44.7)	40 (32.0)	(23.7, 40.3)	24 (39.3)	(26.7, 52.0)	16 (25.0)	(14.1, 35.9)						
Annual household income $\geq$ \$75,000	188 (74.6)	(69.2, 80.0)	97 (74.6)	(67.0, 82.2)	91 (74.6)	(66.8, 82.4)	90 (73.2)	(65.2, 81.1)	52 (85.2)	(76.1, 94.4)	44 (68.8)	(57.1, 80.4)						
Marital status, married or partnered	214 (81.4)	(76.6, 86.1)	113 (83.1)	(76.7, 89.5)	101 (79.5)	(72.4, 86.6)	102 (81.6)	(74.7, 88.5)	46 (78.0)	(67.1, 88.9)	50 (78.1)	(67.7, 88.5)						
<b>Health insurance</b>																		
Through fire service or local/state government	74 (28.1)	(22.7, 33.6)	45 (33.1)	(25.1, 41.1)	29 (22.8)	(15.4, 30.2)	45 (36.0)	(27.5, 44.5)	22 (36.1)	(23.7, 48.5)	23 (35.9)	(23.9, 48.0)						
Through employer, workplace, or union	133 (50.6)	(44.5, 56.7)	65 (47.8)	(39.3, 56.3)	68 (53.5)	(44.8, 62.3)	56 (44.8)	(36.0, 53.6)	26 (42.6)	(29.9, 55.4)	30 (46.9)	(34.3, 59.4)						
Through direct purchase or spouse	36 (13.7)	(9.5, 17.9)	17 (12.5)	(6.9, 18.1)	19 (15.0)	(8.7, 21.2)	15 (12.0)	(6.2, 17.8)	9 (14.8)	(5.6, 23.9)	6 (9.4)	(2, 16.7)						
None or not sure	20 (7.6)	(4.4, 10.8)	9 (6.6)	(2.4, 10.8)	11 (8.7)	(3.7, 13.6)	9 (7.2)	(2.6, 11.8)	$\leq 5$		$\leq 5$							
Has a primary healthcare provider	244 (92.8)	(89.6, 95.9)	130 (95.6)	(92.1, 99.1)	114 (89.8)	(84.4, 95.1)	119 (95.2)	(91.4, 99.0)	60 (98.4)	(95.1, 100)	59 (92.2)	(85.4, 98.9)						
Visited a healthcare provider in the past 12 months	245 (93.2)	(90.1, 96.2)	133 (97.8)	(95.3, 100)	112 (88.2)	(82.5, 93.9)	119 (95.2)	(91.4, 99)	60 (98.4)	(95.1, 100)	59 (92.2)	(85.4, 98.9)						
Ever worked as a career firefighter	51 (19.4)	(14.6, 24.2)	29 (21.3)	(14.4, 28.3)	22 (17.3)	(10.7, 24.0)	32 (25.6)	(17.8, 33.4)	18 (29.5)	(17.7, 41.3)	14 (21.9)	(11.5, 32.3)						

(Continues)

TABLE 4 (Continued)

Characteristics	Eligible for colon cancer screening (n = 263)		Received colon cancer screening (n = 136)		Did not receive colon cancer screening (n = 127)		Eligible for prostate cancer screening (n = 125)		Received prostate cancer screening (n = 61)		Did not receive prostate cancer screening (n = 64)	
	mean	95% CI	mean	95% CI	mean	95% CI	mean	95% CI	mean	95% CI	n (mean)	95% CI
Monthly firefighting calls												
≤5	71 (27.2)	(21.8, 32.6)	38 (28.1)	(20.5, 35.8)	33 (26.2)	(18.4, 34)	36 (28.8)	(20.8, 36.8)	16 (26.2)	(14.9, 37.6)	20 (31.3)	(19.6, 42.9)
6–10	63 (24.1)	(18.9, 29.4)	35 (25.9)	(18.4, 33.4)	28 (22.2)	(14.9, 29.6)	28 (22.4)	(15.0, 29.8)	18 (29.5)	(17.7, 41.3)	10 (15.6)	(6.5, 24.8)
11–20	76 (29.1)	(23.6, 34.7)	36 (26.7)	(19.1, 34.2)	40 (31.7)	(23.5, 40.0)	30 (24.0)	(16.4, 31.6)	13 (21.3)	(10.7, 31.9)	17 (26.6)	(15.4, 37.7)
>20	51 (19.5)	(14.7, 24.4)	26 (19.3)	(12.5, 26.0)	25 (19.8)	(12.8, 26.9)	31 (24.8)	(17.1, 32.5)	14 (23.0)	(12.1, 33.8)	17 (26.6)	(15.4, 37.7)
Longest-held firefighting rank												
Firefighter	136 (51.7)	(45.6, 57.8)	62 (45.6)	(37.1, 54.1)	74 (58.3)	(49.6, 67.0)	55 (44.0)	(35.2, 52.8)	29 (47.5)	(34.6, 60.4)	26 (40.6)	(28.3, 53.0)
Chief or company officer	62 (23.6)	(18.4, 28.7)	39 (28.7)	(21.0, 36.4)	23 (18.1)	(11.3, 24.9)	33 (26.4)	(18.6, 34.2)	15 (24.6)	(13.5, 35.7)	18 (28.1)	(16.8, 39.4)
Other leadership	65 (24.7)	(19.5, 30.0)	35 (25.7)	(18.3, 33.2)	30 (23.6)	(16.1, 31.1)	37 (29.6)	(21.5, 37.7)	17 (27.9)	(16.3, 39.4)	20 (31.3)	(19.6, 42.9)
Longest-held occupation												
Construction or manufacturing	83 (31.6)	(25.9, 37.2)	37 (27.2)	(19.6, 34.8)	46 (36.2)	(27.7, 44.7)	36 (28.8)	(20.8, 36.8)	18 (29.5)	(17.7, 41.3)	18 (28.1)	(16.8, 39.4)
Government or clerical	85 (32.3)	(26.6, 38.0)	51 (37.5)	(29.3, 45.7)	34 (26.8)	(19, 34.6)	45 (36.0)	(27.5, 44.5)	20 (32.8)	(20.7, 44.9)	25 (39.1)	(26.8, 51.3)
Service provider	66 (25.1)	(19.8, 30.4)	27 (19.9)	(13.1, 26.6)	39 (30.7)	(22.6, 38.8)	27 (21.6)	(14.3, 28.9)	14 (23.0)	(12.1, 33.8)	13 (20.3)	(10.2, 30.4)
Other	29 (11.0)	(7.2, 14.8)	21 (15.4)	(9.3, 21.6)	8 (6.3)	(2.0, 10.6)	17 (13.6)	(7.5, 19.7)	9 (14.8)	(5.6, 23.9)	8 (12.5)	(4.2, 20.8)
All cancer risk perception <sup>c</sup>												
Higher perceived risk	156 (59.3)	(53.3, 65.3)	85 (62.5)	(54.3, 70.7)	71 (55.9)	(47.2, 64.7)	81 (64.8)	(56.3, 73.3)	43 (70.5)	(58.7, 82.3)	38 (59.4)	(47.0, 71.7)
Similar or lower perceived risk	107 (40.7)	(34.7, 46.7)	51 (37.5)	(29.3, 45.7)	56 (44.1)	(35.3, 52.8)	44 (35.2)	(26.7, 43.7)	18 (29.5)	(17.7, 41.3)	26 (40.6)	(28.3, 53)
Parental history of colon or rectal cancer <sup>d</sup>	27 (10.3)	(6.6, 14.0)	19 (14.0)	(8.1, 19.9)	8 (6.3)	(2.0, 10.6)	-	-	-	-	-	-
Father or brother(s) had history of prostate cancer <sup>d</sup>	-	-	-	-	-	-	9 (7.2)	(2.6, 11.8)	≤5	≤5	≤5	≤5

Abbreviations: CAPS, Firefighter Cancer Assessment and Prevention Study; USPSTF, United States Preventive Services Task Force.

Cell values may not add to total sample size due to missing data.

<sup>a</sup>Accounts for both volunteer and career firefighting experience, and their possible overlap.

<sup>b</sup>Other race/ethnicity categories not reported due to small sample sizes.

<sup>c</sup>All cancer risk perception compared to adult non-firefighters of same age.

<sup>d</sup>Biological family members only.

**TABLE 5** Association of receiving colon and prostate cancer screening based on the United States Preventive Services Task Force (USPTF) eligibility with characteristics of volunteer firefighters enrolled in the Firefighter Cancer Assessment and Prevention Study (CAPS) assessed by a multivariable logistic regression.

Predictors	Colon cancer screening (n = 261) OR (95% CI)	Prostate cancer screening (n = 125) OR (95% CI)
<b>Demographics</b>		
Age (years), <sup>ab</sup>	1.18 (1.12, 1.25)	1.11 (1.0, 1.23)
Education (≥some college education vs. ≤high school graduate)	2.09 (1.05, 4.15)	2.9 (1.15, 7.34)
Marital status (married or partnered vs. other)	1.16 (0.55, 2.43)	1.34 (0.47, 3.87)
<b>Firefighting service</b>		
Firefighting service (years) <sup>a</sup>	0.99 (0.97, 1.02)	1.01 (0.97, 1.04)
Monthly firefighting calls		
6–10 vs. ≤5	1.39 (0.61, 3.19)	2.4 (0.82, 7.0)
11–20 vs. ≤5	0.75 (0.35, 1.64)	1.01 (0.36, 2.86)
>20 vs. ≤5	0.97 (0.41, 2.26)	1.08 (0.38, 3.08)
Fire department rank (firefighter vs leadership)	0.66 (0.37, 1.2)	1.42 (0.63, 3.17)
<b>Risk perception</b>		
Cancer risk perception <sup>c</sup> (high vs. lower/similar)	1.68 (0.9, 3.13)	1.57 (0.68, 3.61)
Family cancer history <sup>d</sup> (yes vs no)	0.97 (0.39, 2.43)	–

Abbreviations: CAPS, Firefighter Cancer Assessment and Prevention Study; OR, Odds Ratio; adjusted for other model predictors; USPSTF, United States Preventive Services Taskforce.

n = 261 for colon cancer screening analyses as 2 participants had missing data for monthly firefighting calls

<sup>a</sup>Age and years of firefighting service included as continuous variables.

<sup>b</sup>Accounts for both volunteer and career firefighting experience, and their possible overlap

<sup>c</sup>Cancer risk perception compared to same-aged non-firefighters

<sup>d</sup>For colon cancer screening, family cancer history includes biological father and mother only. For prostate cancer screening, family cancer history not included as a covariate due to small sample size.

control into routine firefighter education and training programs may have substantial impact. Conducting further research on cancer screening practices within volunteer fire departments and encouraging volunteer firefighters to discuss screening with healthcare professionals can help fill the existing gaps in screening for this underrepresented population.

## AUTHOR CONTRIBUTIONS

Conceptualization: Nimit N. Shah, Judith M. Graber, Michael B. Steinberg. Formal Analysis: Nimit N. Shah. Writing—original draft: Nimit N. Shah, Judith M. Graber. Writing—review and editing: Nimit N. Shah, Michael B. Steinberg, Miriam M. Calkins, Alberto J. Caban-Martinez, Elena Austin, Jeffery L. Burgess, Brittany S. Hollerbach, Derrick Edwards, Taylor M. Black, Kathleen Black, Kaleigh M. Hinton, Brian S. Kubieli, Judith M. Graber. Project Administration: Taylor M. Black, Kaleigh M. Hinton, Kathleen Black, Nimit N. Shah.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

## DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

## DATA AVAILABILITY STATEMENT

Requests for a limited data set will be reviewed on a case-by-case basis by the principal investigator (PI), Judith Graber, PhD, MS who

can be reached at [judith.graber@rutgers.edu](mailto:judith.graber@rutgers.edu). Any data sharing would require a fully executed institutional Data Use Agreement as well as approval by the PIs' institutional review boards and the Rutgers Cancer Institute of New Jersey Scientific Review Board.

## INSTITUTION AND ETHICS APPROVAL AND INFORMED CONSENT

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