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A cross-sectional assessment of the individual- and fire department-level factors affecting volunteer firefighter cardiorespiratory fitness

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Abstract

Volunteer firefighters often have lower cardiorespiratory fitness (CRF) and less access to health monitoring and fitness programs than career firefighters, yet few studies explore how individual and departmental factors influence their CRF. This study assessed associations between CRF and both firefighter-level (e.g., years of service, firefighting calls, and firefighter rank) and department-level (e.g., department characteristics and fitness infrastructure) factors among volunteer firefighters. Surveys were administered to United States volunteer firefighters and departments, capturing CRF and related characteristics. CRF was analyzed as both a continuous and categorical variable (≤ 8 , $>8-10$, $10-12$, ≥ 12 METs) using bivariate analyses and mixed

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INFORMED CONSENT STATEMENT

Electronic informed consent was obtained for each participant.

CONFLICTS OF INTEREST

Authors S.A.J. and B.S.H. were employed by NDRI-USA, Inc. The remaining authors (N.N.S., D.L.E., J.R., O.A.W., A.J.C.-M., T.M.B., K.H., B.S.K., C.D.D., and J.M.G.) declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The authors declare no conflicts of interest.

effects linear and logistic regression. Among 569 incumbent volunteer firefighters from 41 departments, 79.9% did not meet the recommended 12 METs threshold. Only 56.8% of departments provided routine physical exams; 35.1% had a wellness coordinator or committee; and 40.5% offered fitness resources. More years of service were associated with lower CRF and reduced odds of meeting the 12 METs benchmark, while more frequent training and responding to more calls were associated with better CRF. These findings highlight individual and structural challenges for CRF in volunteer fire service, underscoring the need for targeted fitness support to protect firefighter health and community safety.

Keywords

Cardiorespiratory fitness; volunteer fire departments; volunteer firefighters

INTRODUCTION

Firefighters engage in physically demanding tasks, often in unstable environments. Optimal firefighter physical fitness is vital to ensuring their safe and efficient work performance and reducing the risk of health problems. Growing evidence suggests that cardiac events are the primary contributor to line-of-duty fatalities among firefighters [1,2,3], and firefighting as an occupation is associated with an elevated risk of injuries and certain cancers [4,5]. Cardiorespiratory fitness (CRF), a measure of the circulatory and respiratory systems' ability to transport oxygen to the body's cells during physical activity [6], is an important health indicator for firefighters as it is inversely associated with these adverse firefighter health conditions [7,8,9,10].

The US-based National Fire Protection Association (NFPA), a non-profit organization that develops firefighter health and safety standards through its Standard on Comprehensive Occupational Medical Program for Fire Departments (NFPA 1582), recommends that firefighters maintain a minimum CRF of 12 metabolic equivalents (METs), or 42 mL/kg/min of oxygen, aligning with CRF requirements for essential firefighting tasks including climbing, lifting, extricating, carrying, and dragging—all often performed while wearing heavy turnout gear [11]. This CRF benchmark has been used to characterize firefighter physical demands since the 1990s [12]. The NFPA advises fire departments to provide job-related fitness counseling for firefighters below the 12 METs CRF recommendation, prescribe an aerobic fitness program for those under 10 METs, and consider restricting essential firefighting tasks along with the fitness program prescription for those below 8 METs [13].

Volunteer firefighters comprise 65% of the US fire service [14]. However, large cross-sectional studies show that about 75% of US volunteer firefighters are unable to meet the NFPA CRF recommendation, compared to 61% of career firefighters [15,16]. Although volunteer firefighters tend to respond to fewer firefighting calls compared to career firefighters and generally serve in rural and low-population-density suburban communities (less than 25,000 people), volunteer firefighters have similar firefighting responsibilities as career firefighters [14]. Volunteer firefighters also generally spend less time in their fire

stations due to their full-time jobs [17]. Their length of service, changes in ranks and duties, and competing responsibilities may contribute to their lower CRF.

The NFPA recommends fire departments provide periodic health screenings and physical examinations for firefighters, including physical fitness evaluations [13]. However, volunteer fire departments generally have limited resources to provide their members access to recommended routine occupational health monitoring and evaluations [14,17,18]. A US-based qualitative study of volunteer firefighters' perspectives on factors influencing their physical fitness reported that work and family responsibilities and the unpredictability of calls deprioritized physical activity, while department fitness resources and advocates promoted physical activity [19].

Evidence suggests that volunteer fire departments face challenges in providing fitness-related support to their volunteers, despite departmental support being associated with improved fitness [18]. Research on the combined impact of fire department-level factors and individual firefighter characteristics on firefighter CRF is lacking, especially among volunteer firefighters, an understudied majority of the US fire service. There is a need for such studies to provide guidance on promoting and maintaining fitness among volunteer firefighters and their departments. Therefore, this study aims to investigate associations between volunteer firefighters' CRF and individual factors (e.g., fire service experience), as well as their volunteer fire departments' characteristics (e.g., fitness resources and training).

MATERIALS AND METHODS

Study Design and Population

This cross-sectional study is part of the Firefighter Cancer Assessment and Prevention Study (CAPS) [20,21] and was a sub-study of the Fire Fighter Cancer Cohort Study (FFCCS) [22]. Incumbent male and female volunteer firefighters aged 18 years or older from 41 US fire departments in nine states were enrolled in CAPS from July 2019 to January 2023 using convenience sampling. CAPS is approved by the University of Arizona Institutional Review Board. This study is approved by Rutgers, The State University of New Jersey Institutional Review Board. All surveys were conducted online using REDCap, a secure survey management system [23].

Firefighter-Level Survey and Measures

CAPS participants completed a comprehensive enrollment survey which gathered information on fire service experience, demographics, healthcare access, employment history, cancer history, screening practices, and health behaviors. This enrollment survey was developed using an instrument from the FFCCS originally designed for career firefighters [24]. The CAPS survey was adapted to optimize data collection for volunteer firefighters.

Cardiorespiratory Fitness: Survey responses for physical activity rating (PAR), sex, age, and BMI (kg/m², calculated from self-reported height and body weight) were used to estimate CRF by applying an estimation model that was previously published and validated among various populations, including firefighters [6,25,26]. The PAR is an 8-point

self-rating scale of past 30-day physical activity (0–1: inactive, 2–3: moderately active, and 4–7: vigorously active) [25].

CRF was estimated with the equation $CRF = 56.363 + 1.921 (PAR) - 0.381 (age) - 0.754 (BMI) + 10.987 (female: 0, male: 1)$ in mL O₂/kg/min and was converted to METs (1 MET = 3.5 mL O₂/kg/min) [25]. To assess the prevalence of firefighters meeting the NFPA CRF recommendation, CRF was categorized as ≤ 8 , > 8 to < 10 , 10 to < 12 , and ≥ 12 METs.

Demographics: The participants' age, sex, race, ethnicity, marital status, education attainment, household income, and current employment status were collected using standard questions similar to those used by the Behavioral Risk Factor Surveillance System [27].

Years of Firefighting Service and Calls: Years of firefighting service were determined, accounting for both volunteer and, if applicable, career fire service. This measure was categorized into approximate tertiles as < 10 , 10 to < 30 , and ≥ 30 years. The participants' average number of monthly firefighting calls responded to were categorized as ≤ 5 , 6 to ≤ 10 , 11 to ≤ 20 , and > 20 calls.

Rank and Tasks: The participants' rank was categorized as “firefighter” (firefighter, driver operator, inspector, fire investigator, fire police), “company officer” (lieutenant, captain), or “chief officer” (battalion, deputy, fire, EMT/paramedic, or other chief). The participants' current firefighting tasks were classified into fire-related interior operations, fire-related exterior operations, overhaul and investigation, wildland fire operations, rescue operations, emergency medical services (EMS), and hazardous material (hazmat) operations.

Time Spent in the Fire Station: The firefighters estimated their average monthly hours spent at their fire station(s) on training, meetings, maintenance, and other activities. These estimates were converted to weekly hours and categorized into tertiles: < 3 , 3 to < 8 , and ≥ 8 h per week.

Fire Department-Level Survey and Measures

Between March and June 2023, the contact persons at CAPS-participating fire departments were asked to complete a survey which collected information on their department membership and organizational structure, training, resources, and health and fitness-related policies and programs. The questions were adapted from the NFPA's Fifth Survey of the Needs of the US Fire Service [18], with additional details on training, fitness resources, and components of physical examinations.

Demographics and Membership: The survey respondents were asked to report the average number of incumbent members in their department within the past year. Additionally, they were asked to report the proportion of their department's membership that fell within specific age groups (18 to 25 years, 26 to 54 years, and 55 years or older) and the number of members currently participating in structural firefighting calls.

Location and Population Served: CAPS fire departments were grouped by state or sub-state county-defined areas, including northern and central New Jersey, coastal New

Jersey, central Maine, southern Maine, Maryland, Connecticut, middle Tennessee, Missouri, and Washington, to maximize the sample size. The survey respondents provided the names of the towns or cities their departments served. The 2020 US Census data were used to retrieve the total population size served by the departments, which was categorized as <5000, 5000 to 9999, 10,000 to 24,999, and $\geq 25,000$ people, consistent with the NFPA Needs Assessment Survey [28]. As an indicator of the department's potential workload, a population-to-department-membership ratio was calculated to standardize the number of people served per member.

Department Offered Health Screening and Programs: The survey respondents were asked whether there was a health, safety, and wellness team or designated person within their department. Additionally, they provided information on whether routine physical examinations, including assessments such as heart rate, aerobic capacity, electrocardiograms, blood pressure, body composition, and lung function, were offered to both members and recruits. The respondents were asked whether their departments required an initial firefighter fitness ability test for new members. The respondents also reported any health or wellness programs provided in the past year, including fitness for duty evaluation, nutritional/dietary education/training, physical health education, or heart attack prevention education. Furthermore, the respondents were asked to report whether their department offered fitness maintenance programs, such as reduced-cost or free gym memberships, on-site exercise equipment, on-site exercise training, or physical activity/fitness education for members.

Budget, Fire Call Volume, and Training: The survey respondents reported their department's annual operating budget, which was categorized into approximate tertiles as <USD 100,000, USD 100,000 to USD 250,000, and >USD 250,000. A budget-to-department-membership ratio was calculated. The average monthly firefighting call volume was categorized as ≤ 20 , >20 to 60, and >60 calls. The survey included questions on the frequency of department membership meetings (once every 1 to 3 weeks, monthly, and every 2 months or more) and fire training (weekly, every 2 to 3 weeks, and monthly or more).

Statistical Analyses

Firefighter- and fire department-level data were linked using department names and the prevalence of characteristics and CRF levels were presented as means and percent frequencies. Bivariate analyses for both firefighter- and fire department-level characteristics compared mean and categorical CRF among volunteer firefighters using 95% confidence intervals (CIs).

Three multivariable mixed effects models were employed: assessing CRF as a continuous variable; evaluating recommended CRF levels (≥ 12 METs vs. <12 METs); and evaluating low CRF (≤ 8 METs vs. >8 METs). For these exploratory analyses, variable selection was based on a priori decisions to assess firefighter and fire department characteristics influencing CRF. Covariates at the firefighter-level included years of firefighting, average monthly fire calls responded to, and current firefighting rank. The fire department-level covariates included the fire department state or sub-state region, the ratio of the population

served to the number of fire department members, the presence of designated health, safety, and wellness personnel, the availability of routine physical examinations, the resources for firefighter fitness maintenance, and the frequency of firefighting training (weekly, every two to three weeks, monthly, or less frequent).

Firefighting experience was modeled continuously as it showed linearity with the continuous form of CRF and with the log odds (with either binary form of CRF) based on visual inspection and Box-Tidwell transformations, respectively [29]. Firefighter level, fire calls per month, and fire department-level population served per member ratio were operationalized as categorical variables as their continuous forms displayed non-linearity with CRF. Although transformations for these variables were considered, they were not implemented to avoid complicating the interpretability of the multivariable findings. All variables were included as fixed effects in the models except for fire department location, which was included as a random intercept. For ease of interpretation, years of firefighting experience was scaled to a 10-year increase in all models. A sensitivity analysis was conducted where the model was restricted to CAPS participants who currently held the rank of firefighter at the time of the survey as these individuals would be more likely to respond to, or be present at, an emergency scene.

Age, BMI, PAR, and sex were excluded from the models to prevent overadjustment as they were used to estimate CRF. Adjusted odds ratios (AOR) and mean change in CRF were reported for logistic and linear regression models, respectively, with 95% CIs. The analyses were conducted using SAS (version 9.4) statistical software.

RESULTS

CAPS researchers enrolled 569 incumbent volunteer firefighters from 41 volunteer or combination departments. Thirty-seven fire departments (90.2%) provided fire department-level data that could be linked to 533 (93.7%) survey responses from CAPS-enrolled volunteer firefighters. Most participants (94.3%) were enrolled during or after 2021.

The participants were predominantly male (90.2%) and non-Hispanic white (92.1%), with an average age of 43.6 years (range: 18 to 82 years) and average fire service experience of 18.6 years (range: <1 to 60 years). Most were employed (83.3%) and 78.1% were employed full-time. Three-fourths of the participants had some college education or higher (74.9%). About one-third (35.1%) held some form of leadership rank at their fire department (Table 1).

Firefighter and Fire Department Characteristics

The average CRF among CAPS volunteer firefighters was 9.5 METs (95% CI: 9.3, 9.7), and most (79.9%, 95% CI: 76.5, 83.3) did not meet the 12 METs NFPA CRF recommendation; 30% reported routine vigorous physical activity in the past month; 42.2% were obese. On average, firefighters spent 11 h per week at their fire station (range: <1 to 126 h/week, including three firefighters who reside at their department). The most common firefighting duties included interior operations (79.4%), exterior operations (77.1%), overhaul or investigation (68.1%), and rescue operations (66.4%; Table 1).

Among the surveyed fire departments, the number of incumbent members ranged from 6 to 250, with 28.7% of members reported as less than 25 years old and 28.5% reported as 55 years or older. Just over half of the departments (56.8%) provided routine physical examinations for their members. About one-third (35.1%) had a health, safety, and wellness person or committee and 40.5% had resources for firefighter fitness maintenance, such as reduced-cost or free gym memberships, on-site exercise equipment, on-site exercise training, or physical activity/fitness education. About one-fourth (27.0%) of the departments required members to take an initial firefighter fitness ability test. Most departments (73.0%) held monthly membership meetings and fire training every one to three weeks (70.2%; Table 2).

Association of CRF with Firefighter and Fire Department Characteristics

Participants who were company or chief officers had lower average CRF (8.9 and 8.0 METs, respectively) compared to firefighters in non-leadership roles (10.0 METs). Additionally, firefighters with less than 10 years of service had a higher mean CRF of 11.1 METs, compared to those with more years of service (10 to <30 years: 9.2 METs; ≥ 30 years: 7.6 METs). The average CRF remained similar across categories of monthly firefighting calls and hours spent at the fire station (Table 3). CRF levels by the demographic, fitness, and fire service characteristics of CAPS firefighters are available in Supplementary Table S1.

Over half of participants (61.7%) with a CRF of ≥ 12 METs and less than half of those with a CRF < 12 METs were members of departments that held weekly fire trainings (Supplementary Table S2). No differences in participants' CRF were observed between departments with varying health and fitness resources, such as having a health, safety, and wellness committee or person, physical fitness testing in routine exams, or programs/resources for fitness maintenance or health promotion (Table 4).

The multivariable analyses showed an inverse relationship between mean CRF and more years of firefighting service (-0.95 METs). Also, more years of firefighting service were associated with increased odds of low CRF (AOR: 1.93) and decreased odds of meeting the 12 METs recommendation (AOR: 0.29). The odds of meeting the 12 METs recommendation had a positive exposure–response relationship with responding to more monthly firefighting calls, although this relationship was not observed in the other models. The mean CRF was lower for participants in departments serving larger communities. In comparison to departments with weekly firefighting training, those with less frequent training had marginally lower mean CRF, increased odds of poor CRF, and decreased odds of meeting the 12 METs recommendation. No notable associations were observed between firefighter CRF and department health and fitness characteristics (Table 5). The sensitivity analysis did not show any meaningful changes in estimates (Supplementary Table S3).

DISCUSSION

This study is one of the first to examine volunteer firefighter and fire department characteristics in the context of CRF. Significant gaps were found in a recommended cardiovascular health indicator for these firefighters and as their department's infrastructure for supporting CRF. Over 79% of the volunteer firefighters in this study did not meet the NFPA's 12 METs recommendation for firefighter duty, suggesting that most volunteers in

this study may have challenges performing firefighting tasks that are physically demanding. Just over a third of volunteer fire departments had a designated health, safety, and wellness person or committee, along with resources for fitness maintenance. Only half of the departments provided routine physical examinations to their members and recruits, which NFPA recommends occur annually.

If NFPA CRF recommendations for fire departments were applied, nearly a third of the CAPS-enrolled volunteer firefighters in this study should not perform essential firefighting tasks and 60% of participants would require aerobic fitness programs [13]. The degree to which participants in this study did not meet the 12 METs CRF recommendation was similar to that in other large US-based cross-sectional studies involving volunteer firefighters [15,16]. The CAPS volunteer firefighters also had a similar prevalence of overweight or obesity (81.9%) compared to a prior estimate for volunteer firefighters (78.4%) [16].

In the US, volunteer fire departments predominantly serve communities with under 25,000 people [14]. This study found that volunteer firefighters in departments serving larger communities had lower average CRF. While these departments tend to have more resources, they may also have more members, including older firefighters, which could contribute to lower average CRF. However, at the individual level, we observed a positive association between CRF and the number of calls responded to per month. This suggests that more active firefighters, regardless of department size, may have higher CRF, potentially due to greater physical demands or engagement in exercise to maintain readiness.

The 2020 US Fire Department Needs Assessment conducted by the NFPA found that 71% of surveyed volunteer or mostly volunteer departments lacked a basic firefighter fitness program, compared to 27% of career or mostly career departments. Similarly, 58% of volunteer departments did not provide medical or physical evaluations to their members, compared to 22% of career departments [18]. In comparison, our study found that a lower proportion (59.5%) of volunteer fire departments did not offer firefighter fitness resources or programs, suggesting a potential improvement. Additionally, the proportion of departments in our study that provided some form of routine physical examination (56.8%) was similar to the NFPA estimate (58%). Interestingly, despite the evidence supporting the benefits of these department programs, this study did not show any major associations between them and volunteer firefighter CRF [30]. In contrast, a US-based cross-sectional study compared career fire departments with fitness programs to those without these programs and observed that firefighters from departments with fitness programs had lower odds of being obese, five times greater odds of meeting the NFPA CRF benchmark, and generally had better fitness compared to those in departments without fitness programs [30]. A qualitative study of CAPS participants found that volunteer firefighting duties are challenging to balance with the work–life commitments and hinder participation in job-related physical fitness activities [19].

This study has some limitations. First, the small number of fire departments may hinder our ability to observe any true differences, especially in the multivariable analyses. Second, there may be selection bias due to the sampling approach, with fire departments having leadership and members potentially being more aware of health issues related to firefighting and more

likely to enroll. This has the potential to increase reported physical activity levels and therefore increase the estimated CRF. In contrast, CAPS data collection occurred during and immediately after the COVID-19 pandemic, which may have reduced firefighters' physical activity and increased their BMIs, thereby lowering their estimated CRF. The effect of the COVID-19 pandemic was not assessed in this study. Third, a CRF estimation model was used instead of direct measurement methods, as it is more cost-effective and practical for assessing large samples of volunteer firefighters. This model specifically relies on the PAR, which is used by CAPS and FFCCS researchers to assess firefighters' physical activity levels. Although the CRF estimation model has been validated, it has lower precision for estimating CRF between 11 and 13 METs for firefighters [25] and uses a sex-related slope that may not fully generalize to females, so some caution is warranted when interpreting CRF among 40% of volunteer firefighters with CRF above 10 METs, and none of the female CAPS participants, who made up 9.8% (n = 52) of the CAPS sample, met the 12 METs recommendation. Fourth, while this study did assess whether fire departments had one or more health, safety, and wellness personnel or a committee, it did not assess this further (e.g., number of personnel or when committee/position was created), which impacted our ability to interpret the finding that CAPS departments with such person or committee were similar in terms of CRF measures to departments without them.

This study also has notable strengths. It includes geographic variation and representation from both rural and suburban departments. CRF was categorized using established recommendations from the NFPA (≤ 8 , > 8 to < 10 , and 10 to < 12 METs), and volunteer firefighter estimated CRF was reported based on these levels, in addition to the recommendation for optimal firefighter CRF (≥ 12 METs). Furthermore, this study explores volunteer firefighter- and fire department-specific characteristics, identifying critical aspects of volunteer firefighters' fitness improvement and maintenance.

Conclusions

The US Fire Administration (USFA) and the National Volunteer Fire Council identify six key challenges, including firefighter health, which is vital for the safety of both volunteer firefighters and the communities they serve [17]. In 2023, the USFA cited recruitment and retention as the biggest challenge for volunteer fire departments [31]. Departments struggling with membership may deprioritize fitness, potentially impairing firefighters' ability to perform critical tasks. While tailored health programs offering flexible exercise options exist for different locations (gym, at-home, and the fire station), many departments lack the resources to implement them [32].

This study underscores the importance of addressing the unique challenges facing volunteer firefighters, emphasizing individual and departmental strategies for promoting and maintaining optimal job-related CRF. Further research on fitness infrastructure and fitness evaluation within volunteer fire departments, with a focus on tailored interventions, can help bridge existing gaps for this underrepresented firefighter population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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DATA AVAILABILITY STATEMENT

Requests for a limited dataset 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. 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.

ABBREVIATIONS

The following abbreviations are used in this manuscript:

CRF	Cardiorespiratory fitness
METs	Metabolic equivalents
NFPA	National Fire Protection Association
CAPS	Firefighter Cancer Assessment and Prevention Study
FFCCS	Fire Fighter Cancer Cohort Study
PAR	Physical activity rating
BMI	Body mass index
AOR	Adjusted odds ratios
CI	Confidence intervals
USFA	US Fire Administration

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Table 1.

Demographic, fitness, and fire service history characteristics of incumbent members of volunteer fire departments enrolled in CAPS (n=533), 2019-2023

	n	%	(95% CI)
Demographic characteristics			
Age (years)			
18 to < 35	187	35.1	(31.0, 39.1)
35 to < 50	144	27.0	(23.2, 30.8)
≥50	202	37.9	(33.8, 42.0)
Sex, male	481	90.2	(87.7, 92.8)
Race/ethnicity, non-Hispanic white	491	92.1	(89.8, 94.4)
Marital status, married or partnered	349	65.5	(61.4, 69.5)
Household Income, ≥ \$ 75,000	313	62.1	(57.9, 66.4)
Education level			
High school or lower	134	25.2	(21.5, 28.9)
Some college	220	41.4	(37.2, 45.6)
College or more	178	33.5	(29.4, 37.5)
Current employment status			
Unemployed	89	16.7	(13.5, 19.9)
Part-time only	28	5.3	(3.4, 7.2)
Full-time only	341	64.0	(59.9, 68.1)
Part-time and full-time	75	14.1	(11.1, 17.0)
Fitness characteristics			
Physical activity level			
Inactive/low	131	24.6	(20.9, 28.2)
Moderate	242	45.4	(41.2, 49.6)
Vigorous	160	30.0	(26.1, 33.9)
BMI (kg/m ²)			
Normal/Healthy (18.5-24.9)	99	18.6	(15.3, 21.9)
Overweight (25.0-29.9)	209	39.2	(35.1, 43.4)
Obese (≥30.0)	225	42.2	(38.0, 46.4)
Estimated CRF Levels according to NFPA 1582 standard ^{a,b}			
≤8 METs	167	31.3	(27.4, 35.3)
>8 to <10 METs	152	28.5	(24.7, 32.4)
10 to < 12 METs	107	20.1	(16.7, 23.5)

	n	%	(95% CI)
≥12 METs	107	20.1	(16.7, 23.5)
Fire service characteristics			
Firefighting rank at current fire department			
Firefighter	346	64.9	(60.9, 69.0)
Company officer	116	21.8	(18.2, 25.3)
Chief	71	13.3	(10.4, 16.2)
Firefighting experience (years) ^c			
< 10	202	37.9	(33.8, 42.0)
10 to < 30	192	36.0	(31.9, 40.1)
≥ 30	139	26.1	(22.3, 29.8)
Average monthly firefighting calls			
≤ 5	151	28.4	(24.6, 32.3)
6 to ≤ 10	118	22.2	(18.7, 25.8)
11 to ≤ 20	145	27.3	(23.5, 31.1)
> 20	117	22.0	(18.5, 25.6)
Time spent in the fire station (hours per week)			
< 3	145	27.2	(23.4, 31.0)
3 to < 8	206	38.6	(34.5, 42.8)
≥ 8	182	34.1	(30.1, 38.2)
Current firefighting and related operations ^d			
Interior operations	423	79.4	(75.9, 82.8)
Exterior operations	411	77.1	(73.5, 80.7)
Overhaul or investigation	363	68.1	(64.1, 72.1)
Wildland fire	265	49.7	(45.5, 54.0)
Rescue operations	354	66.4	(62.4, 70.4)
EMS	205	38.5	(34.3, 42.6)
Hazmat	201	37.7	(33.6, 41.8)

CAPS: Firefighter Cancer Assessment and Prevention Study; CI: Confidence intervals; CRF: Cardiorespiratory fitness; NFPA: National Fire Protection Association; EMS: Emergency Medical Services; METs: Metabolic Equivalents; BMI: Body Mass Index

^aEstimated using age, BMI, gender, and physical activity rating

^bNational Fire Protection Association. NFPA 1582 Standard on Comprehensive Occupational Medical Program for Fire Departments. 2022.

^cAccounts for both volunteer and career firefighting experience, and their possible overlap

^dCategories are not mutually exclusive

Table 2.

Membership, regional, fire service, health resource, and training characteristics of CAPS volunteer fire departments (n = 37), 2023-2024

	CAPS fire departments (n=37)		
	range	mean	(95% CI)
Membership characteristics			
Number of incumbent members in the past year	6 - 250	50.3	(31.7, 68.9)
Fire department age distribution ^{a,b}			
18 to 25 years	0 - 90	28.7	(22.2, 35.2)
26 to 54 years of age	0 - 97	40.5	(31.6, 49.4)
55 years of age or older	0 - 80	28.5	(21.4, 35.7)
Incumbent members participating in structural firefighting calls in the past year ^b	15 - 100	53.5	(46.1, 61.0)
	n	%	(95% CI)
Regional and community characteristics			
State location of fire department			
Northern and central New Jersey	9	24.3	(9.8, 38.8)
Coastal New Jersey	2	5.4	(0.0, 13.0)
Central Maine	3	8.1	(0.0, 17.3)
Southern Maine	1 *	2.7	(0.0, 8.2)
Maryland	2	5.4	(0.0, 13.0)
Connecticut	2	5.4	(0.0, 13.0)
Middle Tennessee	10	27.0	(12.0, 42.0)
Missouri	4	10.8	(0.3, 21.3)
Washington	4	10.8	(0.3, 21.3)
Population size served (people)			
<5,000	14	37.8	(21.4, 54.2)
5,000 to 9,999	9	24.3	(9.8, 38.8)
10,000 to 24,999	4	10.8	(0.3, 21.3)
≥25,000	10	27.0	(12.0, 42.0)
Population served to incumbent membership ratio (people per volunteer member)			
< 150	13	35.1	(19.0, 51.3)
150 to 400	11	29.7	(14.3, 45.2)
> 400	13	35.1	(19.0, 51.3)
Average monthly firefighting call volume			
≤ 20	12	32.4	(16.6, 48.3)
> 20 to 60	11	29.7	(14.3, 45.2)
> 60	14	37.8	(21.4, 54.2)

CAPS fire departments (n=37)			
	range	mean	(95% CI)
Membership characteristics			
Department resources			
Annual budget			
< \$100,000	12	32.4	(16.6, 48.3)
\$100,000 to \$250,000	11	29.7	(14.3, 45.2)
> \$250,000	14	37.8	(21.4, 54.2)
Budget to incumbent membership ratio (\$ per member)			
< \$2,500	12	32.4	(16.6, 48.3)
\$2,500 to \$10,000	11	29.7	(14.3, 45.2)
> \$10,000	14	37.8	(21.4, 54.2)
Health and fitness resources			
Has a health, safety and wellness committee or person	13	35.1	(19.0, 51.3)
Provides routine physical examinations for incumbent members or recruits	21	56.8	(40.0, 73.5)
Require members to complete an initial firefighter physical ability test	10	27.0	(12.0, 42.0)
Provided health promotion or wellness programs in past year ^c	3	8.1	(0.0, 17.3)
Have resources to maintain firefighter fitness ^d	15	40.5	(23.9, 57.1)
Characteristics assessed in physical exams ^a			
Heart rate or aerobic capacity testing	10	27.0	(12.0, 42.0)
Electrocardiograms (EKG)	10	27.0	(12.0, 42.0)
Blood pressure	17	45.9	(29.1, 62.8)
Body composition	6	16.2	(3.8, 28.7)
Lung function testing	9	24.3	(9.8, 38.8)
Departmental trainings and meetings			
Frequency of membership meetings			
1 to 3 weeks	7	18.9	(5.7, 32.2)
Monthly	27	73.0	(58.0, 88.0)
Every 2 months or more	3	8.1	(0.0, 17.3)
Frequency of departmental fire trainings			
Weekly	14	37.8	(21.4, 54.2)
Every 2 to 3 weeks	12	32.4	(16.6, 48.3)
Monthly or more	11	29.7	(14.3, 45.2)

CAPS: Firefighter Cancer Assessment and Prevention Study; CI: Confidence intervals

* Enrollment of volunteer firefighters and departments in Southern Maine was county-based where members from multiple smaller departments in the region enrolled at one department.

^a. Categories are not mutually exclusive.

b. Percent average

c. Health promotion or wellness programs include fitness for duty evaluation, nutritional/dietary education/training, physical health education, or heart attack prevention education

d. Programs to maintain firefighter fitness include reduced cost or free gym memberships, on-site exercise equipment, on-site exercise training, or physical activity or fitness education

Table 3.

Mean cardiorespiratory fitness (CRF) by demographic of CAPS-enrolled incumbent volunteer firefighters by fire department characteristics (n=533)

	Mean CRF ^a (n=533)		
	n	mean	(95% CI)
Demographic characteristics			
Fire department region			
Northern and central New Jersey	91	9.7	(9.2, 10.3)
Coastal New Jersey	120	8.8	(8.3, 9.3)
Central Maine	40	9.3	(8.5, 10.1)
Southern Maine	46	9.0	(8.3, 9.8)
Maryland	33	9.1	(8.2, 10.0)
Connecticut	29	9.9	(8.7, 11.1)
Middle Tennessee	78	9.5	(8.9, 10.0)
Missouri	46	10.2	(9.2, 11.2)
Washington	50	10.8	(10.1, 11.5)
Age (years)			
18 to < 35	187	11.7	(11.4, 12.0)
35 to < 50	144	9.4	(9.1, 9.7)
≥50	202	7.5	(7.3, 7.8)
Sex			
Male	481	9.7	(9.4, 9.9)
Female	52	7.9	(7.2, 8.6)
Race/ethnicity			
Non-Hispanic white	491	9.4	(9.2, 9.7)
Other	42	10.4	(9.6, 11.1)
Household Income			
< \$75,000	191	9.9	(9.5, 10.3)
≥ \$ 75,000	313	9.2	(8.9, 9.5)
Education			
High school or lower	134	9.2	(8.8, 9.7)
Some college	220	9.6	(9.3, 10.0)
College or more	178	9.5	(9.2, 9.9)
Current employment status			
Unemployed	89	8.6	(7.9, 9.2)
Part-time only	28	8.6	(7.3, 10.0)
Full-time only	341	9.8	(9.6, 10.1)
Part-time and full-time	75	9.5	(8.9, 10.1)

Mean CRF ^a (n=533)			
	n	mean	(95% CI)
Demographic characteristics			
Fitness characteristics			
Physical activity level			
Inactive/low	131	7.2	(6.9, 7.6)
Moderate	242	9.1	(8.9, 9.4)
Vigorous	160	12.0	(11.6, 12.3)
BMI (kg/m ²)			
Healthy weight (18.5-24.9)	99	11.1	(10.6, 11.6)
Overweight (25.0-29.9)	209	10.3	(10.0, 10.6)
Obese (≥30.0)	225	8.0	(7.7, 8.3)
Fire service characteristics			
Firefighting rank at current fire department			
Firefighter	346	10.0	(9.7, 10.3)
Company officer	116	8.9	(8.4, 9.4)
Chief officer	71	8.0	(7.6, 8.5)
Firefighting experience (years) ^b			
< 10	202	11.1	(10.7, 11.5)
10 to < 30	192	9.2	(8.9, 9.6)
≥ 30	139	7.6	(7.3, 7.9)
Average monthly firefighting calls			
≤ 5	151	9.2	(8.8, 9.6)
6 to ≤ 10	118	9.7	(9.2, 10.1)
11 to ≤ 20	145	9.6	(9.2, 10.1)
> 20	117	9.6	(9.1, 10.1)
Time spent in the fire station (hours per week)			
< 3	145	9.3	(8.8, 9.7)
3 to < 8	206	9.4	(9.0, 9.7)
≥ 8	182	9.9	(9.5, 10.3)
Current firefighting and related operations ^c			
Interior operations	423	10.0	(9.7, 10.2)
Exterior operations	411	9.7	(9.4, 10.0)
Overhaul or investigation	363	9.9	(9.7, 10.2)
Wildland fire	265	9.9	(9.6, 10.2)
Rescue operations	354	10.0	(9.7, 10.2)
EMS	205	10.0	(9.6, 10.3)

	Mean CRF ^a (n=533)		
	n	mean	(95% CI)
Demographic characteristics			
Hazmat	201	10.1	(9.8, 10.5)

CAPS: Firefighter Cancer Assessment and Prevention Study; CI: Confidence intervals; CRF: Cardiorespiratory fitness; NFPA: National Fire Protection Association; EMS: Emergency Medical Services; METs: Metabolic Equivalents; BMI: Body Mass Index

^aEstimated using age, BMI, gender, and physical activity rating

^bAccounts for both volunteer and career firefighting experience, and their possible overlap

^cCategories are not mutually exclusive

Table 4.

CAPS incumbent volunteer firefighters' (n = 533) cardiorespiratory fitness by their fire departments' (n = 37) membership, regional, fire service, health resource, and training characteristics

	Mean CRF^d (n=533)		
	n	mean	(95% CI)
<i>Regional and community characteristics</i>			
Population size served (people)			
<5,000	199	9.7	(9.3, 10.1)
5,000 to 9,999	80	9.7	(9.1, 10.4)
10,000 to 24,999	48	10.2	(9.5, 10.9)
≥25,000	206	9.1	(8.7, 9.4)
Population served to incumbent membership ratio (people per volunteer member)			
< 150	149	10.0	(9.5, 10.4)
150 to 300	170	9.2	(8.8, 9.6)
> 300	214	9.4	(9.1, 9.8)
Average monthly firefighting call volume			
≤ 20	123	9.8	(9.3, 10.2)
> 20 to 80	105	9.8	(9.2, 10.3)
> 80	305	9.3	(9.0, 9.6)
<i>Department resources</i>			
Annual budget			
< \$100,000	108	9.8	(9.4, 10.2)
\$100,000 to 250,000	154	9.0	(8.6, 9.4)
> \$250,000	271	9.7	(9.3, 10.0)
Department budget to incumbent membership ratio (\$ per member)			
< \$3,000	124	9.6	(9.1, 10.0)
\$3,000 to \$10,000	138	9.1	(8.7, 9.5)
> \$10,000	271	9.7	(9.3, 10.0)
<i>Health and fitness resources</i>			
Have health, safety and wellness committee (or a similar committee) or a person			
Yes	291	9.5	(9.2, 9.8)
No	242	9.5	(9.2, 9.9)
Physical fitness related characteristics assessed in routine physical exams ^a			
Yes	367	9.5	(9.2, 9.8)
No	166	9.6	(9.1, 10.0)
Require members to complete an initial firefighter physical ability test			

	Mean CRF ^d (n=533)		
	n	mean	(95% CI)
Regional and community characteristics			
Yes	191	9.3	(9.0, 9.7)
No	342	9.6	(9.3, 9.9)
Provided any health promotion or wellness programs in past year ^b			
Yes	69	9.4	(8.8, 10.0)
No	464	9.5	(9.3, 9.8)
Have resources to maintain firefighter fitness ^c			
Yes	267	9.6	(9.3, 9.9)
No	266	9.4	(9.1, 9.7)
Departmental Trainings and meetings			
Frequency of membership meetings			
1 to 3 weeks	75	10.2	(9.7, 10.8)
Monthly	408	9.3	(9.0, 9.5)
Every 2 months or more	50	10.4	(9.4, 11.3)
Frequency of departmental fire trainings			
Weekly	255	9.8	(9.4, 10.1)
Every 2 to 3 weeks	117	9.3	(8.8, 9.7)
Monthly or more	161	9.3	(8.9, 9.7)

CAPS: Firefighter Cancer Assessment and Prevention Study; CI: Confidence intervals

^aPhysical fitness related characteristics assessed include heart rate or aerobic capacity testing, electrocardiograms (EKG), blood pressure, body composition, or lung function testing.

^bHealth promotion or wellness programs include fitness for duty evaluation, nutritional/dietary education/training, physical health education, or heart attack prevention education

^cPrograms to maintain firefighter fitness include reduced cost or free gym memberships, on-site exercise equipment, on-site exercise training, or physical activity or fitness education

^dCRF estimated using age, BMI, gender, and physical activity rating.

Table 5.

Association between volunteer firefighter and fire department characteristics with firefighter cardiorespiratory fitness as assessed by mixed effects multivariable linear and logistic regression models (n = 531)

	Change in mean CRF		Unacceptable for Firefighting (≤8) METs vs. Acceptable (>8) METs		Recommended (≥ 12) METs vs. below recommended (< 12) METs	
	β	(95% CI)	AOR	(95% CI)	AOR	(95% CI)
Firefighter-level characteristics						
Firefighting experience (years)	-0.95	(-1.09, -0.81)	1.93	(1.64, 2.26)	0.29	(0.20, 0.42)
Monthly firefighting calls (ref.: ≤ 5)						
6 to ≤ 10	0.65	(0.11, 1.20)	0.67	(0.36, 1.23)	1.85	(0.87, 3.93)
11 to ≤ 20	0.82	(0.27, 1.37)	0.47	(0.25, 0.89)	2.35	(1.08, 5.09)
> 20	0.59	(0.00, 1.19)	0.76	(0.39, 1.48)	2.89	(1.27, 6.62)
Firefighting rank at current fire department (ref.: Firefighter)						
Company officer	-0.43	(-0.91, 0.06)	1.55	(0.92, 2.61)	1.48	(0.74, 2.97)
Chief officer	-0.44	(-1.06, 0.18)	1.25	(0.67, 2.34)	0.36	(0.04, 2.96)
Fire department-level characteristics						
Population served to incumbent membership ratio ^a (ref.: < 150)						
150 to 300	-0.46	(-1.12, 0.20)	1.70	(0.78, 3.72)	1.51	(0.63, 3.62)
>300	-0.85	(-1.49, -0.20)	1.92	(0.89, 4.12)	0.57	(0.25, 1.33)
Have health, safety and wellness personnel (yes vs. no)	0.02	(-0.58, 0.63)	1.10	(0.54, 2.24)	1.14	(0.50, 2.64)
Physical fitness assessed in routine exams ^b (ref.: No)	0.62	(-0.11, 1.34)	0.36	(0.15, 0.87)	0.83	(0.31, 2.20)
Have resources to maintain firefighter fitness ^c (ref.: No)	0.18	(-0.37, 0.74)	0.94	(0.48, 1.83)	1.23	(0.56, 2.69)
Departmental fire trainings						
Every 2 to 3 weeks (ref.: weekly)	-0.36	(-0.98, 0.27)	1.70	(0.81, 3.56)	0.27	(0.11, 0.65)
Monthly or more (ref.: weekly)	-0.16	(-0.85, 0.52)	1.10	(0.50, 2.40)	0.47	(0.18, 1.23)

AOR: Adjusted Odd Ratio, CI: Confidence Interval, CRF: Cardiorespiratory Fitness, METs: Metabolic Equivalents

Fire department region is included as a random effect (random intercept) in each of the three models CRF estimated using age, BMI, gender, and physical activity rating.

For ease of interpretation, years of firefighting experience was scaled to an increase in 10 years in all models n = 2 participants were missing data for monthly firefighting calls

^aNumber of people in the community served per volunteer member

^bPhysical fitness related characteristics assessed include heart rate or aerobic capacity testing, electrocardiograms (EKG), blood pressure, body composition, or lung function testing.

^cPrograms to maintain firefighter fitness include reduced cost or free gym memberships, on-site exercise equipment, on-site exercise training, or physical activity or fitness education

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