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In this Issue

The Dr. John Granito Award

Dr. John Granito Award for Excellence in Fire Leadership and Management Research

The Dr. John Granito Award for Excellence in Fire Leadership and Management Research is presented at the *International Fire Service Journal of Leadership and Management (IFSJLM)* Research Symposium held annually in July at the International Fire Service Training Association (IFSTA) Validation Conference. The Granito Award is presented annually to an individual who has significantly advanced the fire leadership and management literature through their research efforts. The award honors the many contributions and achievements of Dr. John Granito to the scholarly study of fire leadership and management.

Until his retirement, John was one of the premier fire and public safety consultants in the United States. Just a few of his many Fire, Rescue, and Emergency Services research projects include: Oklahoma State University–Fire Protection Publications Line-of-Duty Death Reduction Project (3 years); Centaur National Study (3 years); Research Triangle Institute/National Fire Protection Association/International City/County Management Association Project (4 years); Fire Department Analysis Project (FireDAP) of the Urban Fire Forum (13 years); Combination Department Leadership Project, University of Maryland, Maryland Fire & Rescue Institute (4 years); and the Worcester Polytechnic/International Association of Fire Fighters/International Association of Fire Chiefs/National Institute for Occupational Safety and Health Fire Ground Performance Study. John has participated in more than 400 fire department studies.

John also has strong ties to academia. He served in a number of academic positions for almost 30 years, including 16 years at the State University of New York at Binghamton. He is Professor Emeritus and Retired Vice President for Public Service and External Affairs at SUNY Binghamton, which is consistently ranked among the top public universities by *U.S. News & World Report*.

John has published numerous articles, chapters, and technical papers. He served as co-editor of *Managing Fire and Rescue Services,* a book published by the International City/County Management Association in 2002, and he was a Section Editor of the 2008 NFPA *Fire Protection Handbook*®.

Dr. Granito was the first recipient of the award that was established in his honor to recognize individuals who, like Dr. Granito himself, have made outstanding contributions to the fire service and to academia. Each year the recipient of the Dr. Granito Award presents the Keynote Address at the annual *IFSJLM* Research Symposium. The Keynote Address is subsequently published as the lead article in the next volume of the *International Fire Service Journal of Leadership and Management.*

Recipients of the Dr. John Granito Award for Excellence in Fire Leadership and Management Research

Year	Recipient	Affiliation *May reflect previous affiliation(s)*
Research Symposium 2008	**Dr. John Granito**	Professor and Vice President Emeritus, State University of New York Binghamton, and Fire & Emergency Services Consultant
Research Symposium 2009	**Dr. Denis Onieal**	Deputy U.S. Fire Administrator (ret), Emmitsburg, MD
Research Symposium 2010	**Dr. Lori Moore-Merrell**	U.S. Fire Administrator
Research Symposium 2011	**Dr. Edward T. Dickinson**	Professor and Director of EMS Field Operations, Department of Emergency Medicine, Perelman School of Medicine, University of Pennsylvania
Research Symposium 2012	**Dr. Daniel Madrzykowski**	Director of Research, UL's Fire Safety Research Institute (FSRI), Columbia, MD
Research Symposium 2013	**Dr. Anne Eyre**	Independent Consultant, Trauma Training, Coventry, United Kingdom
Research Symposium 2014	**Chief Dennis Compton**	Former Fire Chief, International Fire Service Training Association, Fire Protection Publications, Oklahoma State University
Research Symposium 2015	**Dr. Denise Smith**	Tisch Family Distinguished Professor, Department of Health and Human Physiological Sciences, Director of First Responder Health and Safety Laboratory, Skidmore College (NY), and Research Scientist, University of Illinois, Fire Service Institute, Champaign, IL
Research Symposium 2016	**Dr. Sara A. Jahnke**	Director and Senior Scientist, Center for Fire, Rescue, and EMS Health Research, NDRI-USA, Inc., Leawood, KS
Research Symposium 2017	**Chief Ronald J. Siarnicki**	Executive Director, National Fallen Firefighters Foundation
Research Symposium 2018	**Dr. Jefferey L. Burgess**	Associate Dean for Research and Professor, Mel and Enid Zuckerman College of Public Health, University of Arizona

Recipients of the Dr. John Granito Award for Excellence in Fire Leadership and Management Research

Year	Recipient	Affiliation *May reflect previous affiliation(s)*
Research Symposium 2019	**Dr. Gavin Horn**	Research Engineer, UL's Fire Safety Research Institute (FSRI), Columbia, MD
Research Symposium 2020-21	***No Recipient***	*Symposium canceled due to the COVID-19 pandemic*
Research Symposium 2022	**Dr. Kenny Fent**	Industrial Hygienist and Team Leader of the National Firefighter Registry Program, Centers for Disease Control and Prevention
Research Symposium 2023	**Dr. Steve Kerber**	Vice President and Executive Director, UL's Fire Safety Research Institute, Columbia, MD
Research Symposium 2024	**Dr. Judith Graber**	Department of Biostatistics and Epidemiology, Rutgers School of Public Health, Rutgers, The State University of New Jersey, Piscataway, NJ

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Double the Service, Double the Risk? Exploring Military Service as a Risk Factor for Health Outcomes in Firefighters

Abstract

This study used secondary data analysis from three national firefighter studies of almost 1,900 veteran and nonveteran firefighters to compare and explain the impact of six personal demographic factors, two occupational characteristics, and 11 health outcomes on each group. Univariate data analysis showed veteran and nonveteran firefighters in our sample shared a large number of similarities. They reported significant statistical differences in only three of the 19 demographic, occupational, and health outcome variables. Veteran firefighters were older than nonveterans and less likely to have a college or advanced degree. Firefighters with military service were also significantly more likely to have a history of divorce. The means or percentages were not statistically significant in the other 13 univariate comparisons. The similarities between veteran and nonveteran firefighters included three demographic characteristics (race, ethnicity, and marital status); both occupational characteristics (rank and years of service); and all 11 health outcomes (previous anxiety diagnosis, previous depression diagnosis, CESD-10, work stress, work stress interference with duties, cigarette smoking, smokeless tobacco use, alcohol use, binge drinking, body mass index, and waist circumference).

A multivariate analysis did show, however, that when controlled for age and educational attainment, one health outcome—a previous anxiety diagnosis—became statistically significant. An analysis of 66 combat veterans found that veterans who had conducted combat patrols or performed other dangerous duties had 3.4 times the rate of diagnosed anxiety disorders than nonveteran firefighters. However, there was no significant difference in the rates of previously diagnosed anxiety disorders between nonveterans and veterans without combat experience. These last two findings carry important policy and training implications for the fire service.

Keywords: military veterans as firefighters, health of military veterans in the fire service, anxiety disorders among firefighters with and without military service

A substantial number of military personnel become firefighters when they retire or separate from active duty. Although veterans represent only 6% of the U.S. population, it is estimated that 19% of firefighters are military veterans (Gerard, 2021). Firefighters and military veterans are occupational groups with many similarities: the desire for public service, an intimate knowledge of the hierarchal power structure, experience operating in extreme teamwork environments, and high rates of trauma from exposure to natural disasters, fires, death (at the emergency scene or on the battlefield), and combat. They also share negative occupational stressors such as long work hours, deployment, high levels of work stress, and frequent separation from family (Bartlett et al., 2019; Drummet et al., 2003; Maguen et al., 2011; Pflanz & Sonnek, 2002; Saijo et al., 2008). These occupational similarities and stressors put both groups at an increased risk for negative health outcomes such as anxiety, depression, work stress, and substance abuse with alcohol and tobacco (see Haddock et al., 2011; Tak et al., 2007; Carleton et al., 2019; Poston et al., 2013; Wagner et al., 2021).

Examples of these negative health outcomes include:

- Anxiety and depression—Approximately 19% of firefighters reported experiencing anxiety. This is a much higher percentage than reported for the general population (Carleton et al., 2019; Wagner et al., 2021). Depression rates among veterans hover around 15%. This rate is higher than the general population (Inoue et al., 2023).
- Tobacco use—Firefighter smokeless tobacco and military cigarette and smokeless tobacco use rates are much higher than the general population rate of 12.5% for cigarettes (Centers for Disease Control and Prevention, n.d.-a) and 2.3% for smokeless tobacco use (Centers for Disease Control and Prevention, n.d.-b).
- Binge drinking—One third of active duty military members engage in binge drinking (Meadows et al., 2018). The rate drops to under 16% for veterans (American Addiction Centers, 2019).

A small, albeit growing, area of research has examined the impact of military service on health outcomes *specifically for firefighters*. This research shows, for example, that military veteran status among firefighters has been linked to an increase in post-traumatic stress disorder (PTSD) and depressive symptoms (Bartlett et al., 2018; Paulus et al., 2018); increased feelings of panic and social anxiety (Paulus et al., 2018); and greater sleep disturbances (Bartlett et al., 2018). The research by Bartlett et al. (2018) and Paulus et al. (2018) has laid a solid foundation for a better understanding of the health concerns associated with military veterans in the fire service. The purpose of this study is to build on that foundation by *comparing and explaining* the impact of six personal demographic factors, two occupational characteristics, and 11 health outcomes for veteran and nonveteran firefighters. The univariate comparisons and multivariate analysis are based on three national samples spanning almost a decade. The sample consisted of responses from almost 1,900 firefighters, including 395 firefighters who had previously served in the military.

Methods

Our data were compiled from three large studies conducted by the Center for Fire, Rescue, and EMS Health Research (CFREHR), an NDRI-USA research center. The study protocol and consent procedures were approved by the institutional review board of the appropriate organization. Each of the three studies, as described below, was a federally funded project designed to examine the health and wellness of firefighters. Sampling methods and procedures for the three studies have been described elsewhere (Haddock et al., 2015; Poston et al., 2013; Poston et al., 2011) and are available from the lead author of this article.

- The Firefighter Injury and Risk Evaluation (FIRE) Study. We include data from this baseline evaluation of a longitudinal cohort study on risk factors for injury in 11 career fire departments in the Missouri Valley Region (Colorado, Iowa, Kansas, Missouri, North Dakota, Nebraska, South Dakota, and Wyoming) of the International Association of Fire Chiefs (IAFC). Data were collected from 2008 to 2010.
- The Fuel-2-Fight (F2F) Study. The F2F baseline data are from a cohort study of the nutrition and health parameters of career firefighters nationwide. The F2F study purposively selected 20 departments in 14 U.S. states, commonwealths, and/or territories and three major U.S. Census Bureau Regions. The departments differed widely in size and number of personnel from large metropolitan departments with thousands of firefighters and more than 100 stations to small departments with fewer than 50 firefighters and only one station. Data were collected from 2010 to 2012.
- The FF Behavioral Health (BH) Study. The BH study was a cluster randomized trial of the National Fallen Firefighters Foundation (NFFF) Stress First Aid Intervention in career fire departments. Baseline data from this study are included in this analysis. Eight U.S. fire departments across the nation were chosen for the trial. Data were collected from 2015 to 2017.

Sampling Approach

All fire departments included in those three studies employed full-time career firefighters. Data were collected while the firefighters were on duty. A two-stage sampling approach was used for all three studies. Fire departments were selected first, followed by the firefighters working at each department. For the FIRE study, fire departments in the IAFC Missouri Valley region were selected at random. For the F2F and BH studies, a purposive sampling approach (Shadish et al., 2002) based on each study's respective inclusion criteria was used to select the departments. All career firefighters in each department were eligible for inclusion.

For small and medium-sized departments, firefighters were census sampled (i.e., all firefighters in a department were counted). For large departments (> 500 firefighters), stations were selected at random, and firefighters in those stations were census sampled. The percentage of female participants in the three studies was very small (3.6%), so only male firefighters were included in the merged dataset.

Data Collection Procedures

All data elements were collected by CFREHR/NDRI-USA personnel from on-duty firefighters. Data for the FIRE and F2F studies were collected on paper assessment forms and transferred to the center database. Data for the BH study were collected on tablet computers with the Qualtrics assessment platform, an online survey collection software.

Measures

Table 1 shows the seven constructs that were available in all three datasets.

Table 1

Seven Constructs Used in FIRE, F2F, and BH Studies

Number	Construct name
1.	*Veteran status* (military veteran or nonveteran)
2.	*Personal demographics* (age, race, ethnicity, education, marital status, divorce history)
3.	*Occupational characteristics* (rank, years in the fire service)
4.	*Body composition* (body mass index [BMI], waist circumference)
5.	*Stress* (work stress rating, work stress interference with duties)
6.	*Mental health* (previous diagnosis of depression, previous diagnosis of anxiety, current depressive symptoms as measured by the CESD-10)
7.	*Substance abuse* (heavy drinking, binge drinking, cigarette smoking, smokeless tobacco use)

Note. Only the FIRE and F2F datasets contained variables for the CESD-10, a commonly used depression screening instrument, or for measures of body composition (BMI and waist circumference).

Our measures were combined into a single dataset for secondary data analysis. The Appendix provides an overview of the variables used from each of the three studies along with the sample sizes available for veteran and nonveteran firefighters. The first three constructs—veteran status, personal demographics, and occupational characteristics—were pretty straightforward to measure. The measures we used for body composition, mental health, and substance abuse require more explanation.

Body Composition

Measures of body composition were objectively measured by NDRI-USA staff at each fire department using standard methods (Poston et al., 2013; Poston et al., 2011). Body mass index (BMI) was computed by dividing weight in kilograms (kg) by height in meters squared (m^2). Participants were classified as obese if their BMI was greater than or equal to 30.0 kg/m^2 (Centers for Disease Control and Prevention, 2022). Waist circumference was measured by the research team during data collection. It should be noted the physical health measures were only assessed in the FIRE and F2F studies.

Mental Health

Our mental health measure consisted of five variables. The first two variables were measures of stress, as shown in Table 1: (a) the amount of work stress and (b) the extent to which work stress interfered with the participant's ability to perform their duties (stress interference). Work stress and stress interference were measured by asking study participants how much on-duty work stress and stress interference they had experienced during the six months prior to the survey/study. Responses were based on a 4-point Likert scale ranging from 3 (*a lot*) to 0 (*none at all*).

The other three mental health measures, as shown in Table 1, included (a) previous diagnosis of depression, (b) previous diagnosis of anxiety, and (c) current depressive symptoms. Current depressive symptoms, captured in two of the three studies (FIRE and F2F), were measured using the 10-item Center for Epidemiological Studies Short Depression Scale (CESD-10). The CESD-10 includes questions about the frequency of feelings and behaviors during the past week (Andresen et al., 1994; Zhang et al., 2012).

Substance Use

Data on alcohol and tobacco use were captured with measures adapted from the Department of Defense Survey of Health-Related Behaviors Among Personnel, the military's main source of information on health behavior (Bray et al., 2003). Career firefighters work in 24-hour shifts at least 10 days per month; more days if they pick up extra shifts. They are not allowed to use alcohol while on shift, and our previous studies have suggested that on-duty alcohol consumption is very rare.

We assessed drinking levels using two items. The first item asked: "During the past 30 days, have you had at least one drink of any alcoholic beverage such as beer, wine, a malt beverage, or liquor?" If a participant answered *no* to this item, they were categorized as "abstinent." If they answered *yes,* they were asked to respond to the second item: "During the past 30 days, on the days when you drank, about how many drinks did you drink on the average?" Based on their responses to the second item, we categorized their drinking pattern as "moderate" (*one or two drinks per day, on average*) or "heavy" (*three or more drinks per day, on average*). This drinking pattern measurement approach is consistent with the one used in our previous studies and with the published drinking guidelines suggested by the Centers for Disease Control and Prevention (n.d.-c).

Our assessment of binge drinking was based on the participants' answer to the following question: "Considering all types of alcoholic beverages, how many times during the past 30 days did you have 5 or more drinks (men) or 4 or more drinks (women) on a single occasion?"

Participants were also asked to provide information about their tobacco use. Cigarette users were classified in one of three ways: current smoker, former smoker, or never smoked. A binary measure of smokeless tobacco (SLT) use was used to capture current SLT users.

Data-Analysis Procedures

For items 2–7 in Table 1, univariate comparisons were calculated for veteran and nonveteran firefighters:

- item 2 (personal demographics)
- item 3 (occupational characteristics)
- item 4 (body composition)
- items 5 and 6 (folded together into our measure of mental health)
- item 7 (substance use)

Given the two-stage sampling strategy used in the FIRE and F2F studies, the randomization approach used in the BH research, and the fact that our seven constructs shown in Table 1 have been found to cluster within departments (thus violating the independence assumption), a mixed modeling strategy was used. This random effect for the fire department was entered into each model as a covariate (Murray, 2020). Generalized linear mixed models were used to predict veteran status, which was fit by maximum likelihood (Laplace Approximation) using the "glmer" function within the R-package "lmer4 (Version 1.1-29)" (RDocumentation, 2022). A multivariate model was executed using the "GLMERSelect" function within the "StatisticsModels" R package (rdrr.io, 2022) to determine the best set of predictor variables for veteran status.

Variables common to all three datasets (FIRE, F2F, and BH) were considered for inclusion in the final multivariate model (i.e., Age, Race (white vs. other), Hispanic, Education (college vs. other), Rank (firefighter vs. other), Current Smoker, Current Smokeless Tobacco Use, Heavy Drinking, Binge Drinking, Depression, Anxiety, Work Stress Rating, Work Stress Interferes with Duties). The random effect of fire department was "forced" entered, and the final model was developed using a backward stepwise approach. The BH dataset contained detailed information on the combat exposure of veteran firefighters. Based on the data provided in the BH study, we categorized firefighters into three groups: nonveterans, veterans without combat experience, and veterans with combat experience. Firefighters were assigned to the third category based on their response to the question: "Did you ever go on combat patrols or have other dangerous duty?" Using a generalized linear mixed model with fire department as a random effect, we examined the association between combat experience and a previous anxiety disorder diagnosis, given the relationship was a significant predictor in the multivariate model described above.

Results

Univariate Comparisons

Table 2 (p. 12) provides univariate comparisons of veteran and nonveteran firefighters for our six personal demographic variables. Three variables were statistically significant. Veterans were older than nonveterans (mean of 39.9 vs. 38.5 years; $p = 0.008$) and less likely to have a college or advanced degree (15.6% vs. 27.6%; $p < 0.001$). Firefighters with military service were significantly more likely to have a history of divorce (28.2% vs. 20.3%; $p < 0.001$) than firefighters without military service. The two groups were similar in terms of race, ethnicity (percent Hispanic), and marital status.

Table 3 (p. 13) shows univariate comparisons of veteran and nonveteran firefighters on our two occupational characteristics. Neither variable was significantly associated with veteran status. Veterans and nonveterans had a similar percentage of officers in their departments (27.6% vs. 25.8%; $X^2 = 0.57$, $p = 0.451$) and years of fire service (14.4 vs. 13.8; $t = -1.59$, $p = 0.211$).

Table 4 (p. 14) presents comparison data for veteran and nonveteran firefighters on three health measures: mental health, substance abuse, and BMI/waist circumference. None of the 11 health indicators that comprised the three measures were statistically significant. However, two health indicators fell just short of significance: previous anxiety diagnosis as part of the mental health measure and cigarette smoking, a substance abuse indicator. Veteran firefighters were more likely to have been previously diagnosed with anxiety than nonveterans (10.0% vs. 8.1%). However, as noted above, the difference was not significantly different when controlling for the random effect of department (Odds Ratio = 1.43, $p = 0.09$). Similarly, although more veterans than nonveterans were current smokers (14.0% vs. 10.0%), the difference was not statistically significant (Odds Ratio = 1.42, $p = 0.07$).

Multivariate Model Predicting Veteran Status

Three variables were retained in the final multivariate model: age, education, and a previous diagnosis of anxiety (see **Table 5, p. 14**). Consistent with the univariate models, veterans were older ($p = 0.004$), less likely to have a college degree ($p < 0.001$), and (controlling for age and education) significantly more likely to have a previous anxiety disorder diagnosis ($p = 0.04$) compared to nonveterans.

Table 2
Univariate Comparisons of Veteran and Nonveteran Firefighters on Personal Demographics

Personal demographics	All	Veteran	Nonveteran	p-value
Age (Mean [SD])	38.8 (9.2)	39.9 (9.4)	38.5 (9.2)	0.008
Race				
White	78.2	74.1	79.3	0.31†
Black	4.6	8.9	3.5	
Hawaiian	7.6	8.0	7.6	
American Indian/Alaskan Native	<0.01	<0.01	<0.01	
Asian	4.6	3.1	4.9	
Other	4.6	5.1	4.4	
Hispanic (%)	10.4	10.5	10.4	0.99
Education (%)				
< High school	<0.1	<0.1	<0.1	< 0.001‡
High school or GED	9.3	15.8	7.7	
Some college	65.0	68.2	64.3	
College graduate	22.4	12.5	24.9	
Advanced degree	2.9	3.1	2.7	
Marital status (%)				
Married	72.5	73.1	72.1	0.390*
Divorced	8.5	11.5	7.7	
Separated	1.3	1.8	1.1	
Never married	12.5	11.0	13.0	
Member of unmarried couple	5.1	2.6	5.9	
Widowed	<0.1	0	<0.1	
Divorce history (%)				
Never	78.2	71.8	79.7	< 0.001
Once	18.3	22.1	17.4	
Two or more	3.6	6.1	2.9	

Note. Percentages may not sum to 100 because of rounding.
*Comparing married or member of unmarried couple with other.
†Comparing white to other. ‡Comparing college graduate or advanced degree vs. other.

Combat Exposure and Anxiety Disorder Prevalence

Figure 1 (p. 15) presents the BH study measures of combat exposure for 66 firefighters with past military service. Of those veteran firefighters, 60% had a history of conducting combat patrols or performing other dangerous duties. A smaller percentage of respondents reported potentially traumatic events: witnessing unit members killed in action (27.7%) or someone hit by incoming or outgoing rounds (23.1%).

A generalized linear mixed model found that veterans who had conducted combat patrols or performed other dangerous duties had 3.4 times the rate of diagnosed anxiety disorders than nonveteran firefighters (38.5% vs. 11.4%, $p < 0.001$). However, there was no significant difference in the rates of previously diagnosed anxiety disorders between nonveterans and veterans without combat experience (11.5%).

Discussion and Limitations

The body of literature examining the impact of military service on health outcomes for firefighters is quite small. To our knowledge, no large data-based study has examined body composition between veterans and nonveterans. The univariate data reported here did not find significant differences, but this finding is important because it is empirically, not anecdotally, based.

Table 3
Univariate Comparisons of Veteran and Nonveteran Firefighters on Occupational Characteristics

Occupational characteristics	All	Veteran	Nonveteran	p-value
Rank (%)				
FF	37.1	40.6	36.1	0.451
FF-paramedic	14.9	11.7	15.8	
Driver-operator-engineer	19.5	18.8	19.7	
Paramedic	0.3	0	0.03	
Lieutenant	7.7	7.1	7.7	
Captain	14.8	14.0	15.1	
Battalion chief	2.9	3.3	2.8	
Deputy chief	0.06	1.3	0.05	
Other chief	0.08	1.8	0.09	
Fire chief	0.04	0.05	0.03	
Other roles	0.09	1.8	0.07	
Years of service (Mean [SD])	13.9 (8.8)	14.4 (8.8)	13.8 (8.7)	0.211

Note. Percentages may not sum to 100 because of rounding.

Previous research has found that veteran firefighters report an increase in post-traumatic stress disorder (PTSD), depressive symptoms (Bartlett et al., 2018; Paulus et al., 2018), panic disorder, and social anxiety (Paulus et al., 2018). Although our study asked participants to self-report any previous anxiety diagnosis, we did not directly assess PTSD, panic disorder, or social anxiety as previous studies have done.

We did not find a statistically significant difference in previous anxiety diagnoses between veteran and nonveteran firefighters in our univariate comparisons. However, when we controlled for education and age in our multivariate analysis, the effect of military service on previous anxiety diagnoses among veteran firefighters was statistically significant. These data support previous findings about the impact of military service on depressive symptoms among veteran firefighters and show the value of using multivariate analyses to determine the independent effects of those variables.

Very few previous studies have included measures of substance use, and the findings have been contradictory. For example, Paulus et al. (2017) found that veteran firefighters reported higher rates of alcohol use than nonveterans, while Bartlett et al. (2018) found no difference in alcohol use between the two groups. Our data findings support the results of the Bartlett study (see Table 4, p. 14).

As with all fire service research, sampling is a barrier to obtaining generalizable findings. Without a national database for sampling, it is impossible to derive a probability sample of firefighters. As Paulus et al. (2017) have noted, future studies should use samples that include multiple departments and geographic regions to enhance the generalizability of findings. The samples used in our research attempted to address these needs. Our findings are based on three samples drawn from multiple career fire departments, large and small, located in different U.S. geographic regions. The FIRE study included 11 career fire departments in eight states. The F2F study sampled 20 career departments in 14 states, commonwealths, and/or territories in three major U.S. Census Bureau regions. The BH study included eight U.S. career fire departments in locations across the nation. In terms of sample representativeness, this study provides the best picture of veteran and nonveteran firefighters currently available.

Finally, data findings are exclusively for male firefighters. Given that women account for less than 5% of firefighters and few departments have more than a handful of women, studying female veterans in the fire service is a challenge.

Table 4

Univariate Comparisons of Veteran and Nonveteran Firefighters on Health Measures

Health measures	All	Veteran	Nonveteran	p-value
Mental health				
Previous anxiety diagnosis (%)	8.4	10.0	8.1	0.09
Previous depression diagnosis (%)	8.2	8.4	8.2	0.656
CESD-10 (Mean [SD])	3.6 (1.69)	4.03 (1.92)	3.75 (1.67)	0.410
Work stress rating (%)				
A lot	14.2	14.0	14.2	0.683†
Some	39.7	38.9	40.0	
A little	36.2	34.7	36.8	
None	9.9	12.2	9.1	
Work stress interfered with duties (%)				
A lot	1.5	1.8	1.5	0.331†
Some	10.5	13.0	9.8	
A little	22.2	18.1	23.3	
None	65.7	67.2	65.5	
Substance abuse				
Cigarette smoking (%)				
Never smoker	34.7	32.0	35.4	0.07
Ex-smoker	54.5	54.1	54.6	
Current smoker	10.8	14.0	10.0	
Smokeless tobacco (%)	35.9	33.9	36.7	0.88
Alcohol use (%)				
Abstinent	14.4	17.3	13.4	0.21‡
Moderate	47.9	46.5	48.4	
Heavy	37.6	36.2	38.3	
Binge drinking (%)	48.4	46.2	49.1	0.12
BMI and waist circumference				
Body mass index (Mean [SD])	28.6 (4.3)	28.7 (4.8)	28.1 (4.2)	0.11
Waist circumference (Mean [SD])	38.3 (4.6)	38.3 (4.6)	37.9 (4.4)	0.17

Note. Percentages may not sum to 100 because of rounding. All models included a random effect for fire department. CESD-10, BMI, and waist circumference data were only available from the FIRE and F2F datasets.
†Analyzed as a numeric variable. ‡Comparing heavy drinking with other (moderate and abstinent).

Table 5

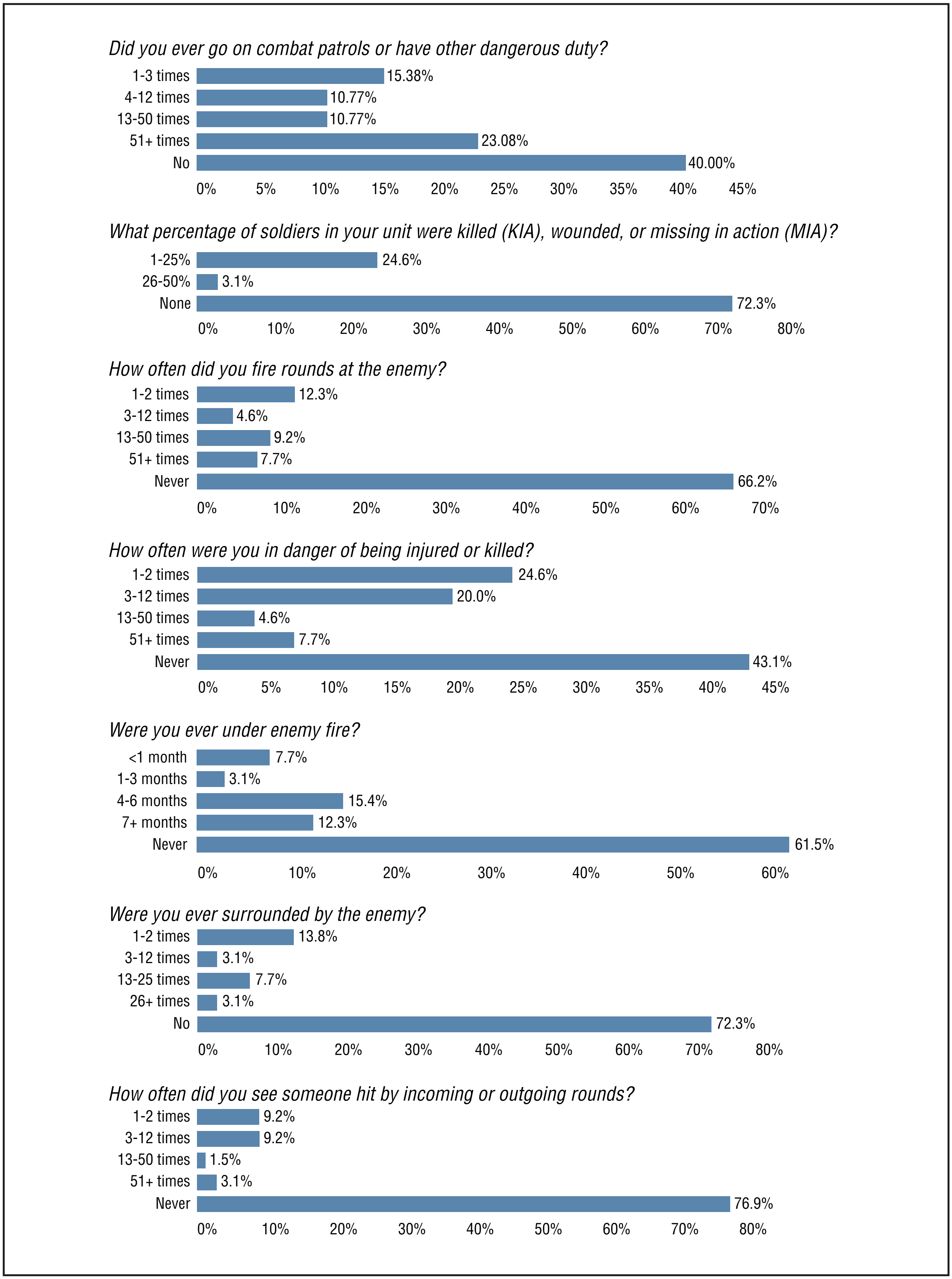
Parameters for Multivariate Model Predicting Veteran Status

Fixed effect	Estimate	Standard error	z-value	p-value
(intercept)	-1.49	0.23	-6.37	<.001
Age	8.42	2.89	2.91	0.004
Education	-0.97	0.26	3.70	<0.001
Anxiety diagnosis	0.61	0.29	2.09	0.04

Note. Education was a factor with two levels: College Graduate or Above and Other (reference category). Anxiety diagnosis was a factor with two levels: Anxiety Diagnosis and No Anxiety Diagnosis (reference category).

Figure 1

Combat Experiences of Veteran Firefighters (N=66)



Conclusion

The U.S. fire service appears to be an attractive option for military veterans. Many veterans bring valuable experience and training to firefighting and adapt well to its occupational culture. Based on our findings, the primary recommendation for future research is to examine the relationship between veteran status and combat exposure in a more granular fashion. The increased risk of anxiety in veteran firefighters with previous combat exposure may predict a more complex relationship between military experience and health outcomes than alluded to by previous literature. Understanding the impact of combat exposure on future job-related mental health outcomes would be valuable when designing and developing resilience-building programs in the fire service.

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Appendix

Measures Available from Three Studies (N = 1,893)

Element	FIRE Study Total N = 461 N Vets = 139	F2F Study Total N = 948 N Vets = 191	BH Study Total N = 484 N Vets = 65
Exposure: veteran status	X	X	X
Combat exposure			X
Clustering random effect (department)	X	X	X
Previous depression diagnosis	X	X	X
Previous anxiety diagnosis	X	X	X
CES-D 10 depression screener	X	X	
Work stress rating†	X	X	X
Work stress interfered with duties†	X	X	X
Cigarette smoking	X	X	X
Smokeless tobacco use	X	X	X
Heavy drinking	X	X	X
Binge drinking	X	X	X
Body mass index	X	X	
Waist circumference	X	X	
Race	X	X	X
Hispanic	X	X	X
Marital status	X	X	X
Age	X	X	X
Divorce history	X	X	X
Education	X	X	X
Years in the fire service	X	X	X
Rank in the fire department	X	X	X

†For work stress, Fuel-2-Fight uses a 6-month time frame. FIRE and Behavioral Health use a 12-month time frame.

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Predictors of Safety Climate Outcomes in Firefighting

Abstract

Safety climate refers to the perceived value an organization places on safety at a specific point in time. To determine key predictors of safety climate in the fire service, we distributed a questionnaire to 105 career firefighters in a Swedish city of approximately 110,000 and analyzed their responses. We used these data to investigate the role of individual, work-group, and organizational factors (independent variables) on three safety climate outcomes (dependent variables): (a) compliance with safety regulations, (b) frequency of unsafe behaviors, and (c) frequency of errors and mistakes in line-of-duty firefighting.

Factors at the individual level included personal risk taking, identity as a firefighter, emotional exhaustion, and work pressures. Hierarchical regression analyses show that these factors explained most of the variance in our three safety climate outcomes, making individual-level variables the most important predictors.

Compliance with safety regulations was predicted by identity as a firefighter (an individual-level variable) and two work-group factors: supervisory support and group cohesion. The importance of these work-group, interpersonal variables highlights the need for supportive and caring leaders who work to increase group cohesion among firefighters. The frequency of generally unsafe behaviors was predicted by the two individual-level factors, personal risk taking and work pressure. This finding suggests more effort should be put into understanding how the work situation as a firefighter impacts risk taking. Finally, the frequency of errors and mistakes was predicted by emotional exhaustion (an individual-level variable). This finding supports previous findings by Smith et al. (2018) and emphasizes the need for additional research on chronic stressors among firefighters and on the impact of those stressors on risk behaviors in line-of-duty firefighting.

Keywords: firefighting, safety climate, firefighters' compliance with safety regulations, unsafe safety behavior, risk analysis, safety management

Safety climate refers to an overt expression of organizational safety culture (Guldenmund, 2000) and is directly related to safety outcomes (Zohar, 2010; Nahrgang et al., 2010; Clarke, 2006). Although it has been studied in risk-taking occupations such as aviation (O'Connor et al., 2011), emergency medicine (Sacks et al., 2015), and the oil and gas industries (Dahl & Kongsvik, 2018; Mearns et al., 2003), relatively few studies have examined safety climate in the fire service (DeJoy et al., 2017).

Our research contributes to the study of the firefighting safety climate by investigating the predictive power of eight safety climate factors (our independent variables) on three self-reported safety climate outcomes (our dependent variables). We assessed the impact of these safety climate factors using the "level of influence" framework presented by DeJoy et al. (2017).

Dejoy et al. (2017) used focus groups to identify potential dimensions of safety climate that were unique to the fire service. In their study, participants were frontline firefighters, station-/company-level officers, and senior department leaders from two large metropolitan fire departments in the United States. The results of their study revealed that a department's safety climate is multidimensional. The individual firefighter, the work-group context, and the organizational environment all contribute to the safety climate of firefighting.

Three Levels of Influence on Safety Climate Outcomes

Individual Level

The individual level in the framework advanced by DeJoy et al. (2017) consists of four factors: personal risk taking, identity as a firefighter, emotional exhaustion, and work pressure. We focused on these individual-level variables as possible explanations for different safety climate outcomes. First, we studied the connection between personal risk taking and safety climate. Salters-Pedneault et al. (2010) have suggested that, because firefighter recruits tend to be high excitement-seekers, personal risk taking may affect their prevailing safety climate. Findings outside the scope of firefighting similarly show that risk-taking attitudes are related to an increase in risk behaviors (Pearson at al., 1995).

Secondly, we hypothesized that a more positive identification as a firefighter is related to better safety climate outcomes. Van Knippenberg (2000) has shown that an individual's identification with a specific work organization can positively influence their motivation and work performance. According to Falomir-Pichastor et al. (2009), the degree to which an individual identifies with a specific occupational group also predicts their level of compliance with safety behaviors.

Next, we looked at the impact of emotional exhaustion and work pressure on the safety climate in firefighting. Research specific to firefighters (Smith et al., 2018) has shown that emotional exhaustion (also called "burnout" in this article) is related to an increase in unsafe behaviors. Meta-analytic data (Nahrgang et al., 2010) showed that exhaustion/burnout contributed to more errors and mistakes at work. Work pressure has also been indirectly identified as an important predictor of safety climate (Maglio et al., 2016). Studies outside the scope of firefighting (Bronkhorst, 2015) have supported this idea. For example, individuals experiencing work pressure practice fewer physical and psychosocial safety behaviors, which leads to increased risk taking (Kierkegaard et al., 2018).

Work-Group Level

The work-group level in the framework advanced by DeJoy et al. (2017) consists of three factors: group cohesion, supervisor support, and supervisor competence. Previous studies that investigate safety climate in firefighting have studied the influence of these independent variables. For example, Smith et al. (2019b) found that group cohesion and supervisor support had a positive effect on the safety climate of U.S. firefighters. Similarly, Smith and DeJoy (2014) investigated 398 U.S. firefighters and found that supervisor support for safety contributed to safety compliance and safety participation behaviors.

Maglio et al. (2016) suggested that work-group identity had a negative and positive effect on PPE compliance. Situation aversion refers to an individual's tendency toward unsafe behaviors as a way to avoid ridicule or harassment by their peers. Not surprisingly, situation aversion was reported to have a negative impact on PPE compliance among firefighters. Conversely, organizational solidarity—support from colleagues and leadership—seems to increase firefighter compliance with PPE requirements.

Finally, Taylor et al. (2019) constructed a self-report scale to assess the safety climate in the fire service. Their scale was developed through qualitative interviews and focus groups and has been validated through a quantitative sample of 8,575 firefighters. Subsequent analysis of their scale revealed that supervisor support influenced safety compliance behaviors and lower injury rates.

Organizational Level

The third level in the model advanced by DeJoy et al. (2017) consists of organizational factors such as politics, bureaucracy, resources, leadership, hiring, and promotion. Leadership is the independent variable that has received the most attention in previous studies. Smith et al. (2019b) found that management commitment, programs and policies, perceived fairness, and incident command were all related to safety climate at the organizational level.

Similarly, management's commitment to safety programs, policies, and communication positively influenced the safety climate in Smith and DeJoy´s study (2014). They concluded that both work-unit level and organizational-level factors contributed to the safety climate of firefighters. Taylor et al. (2019) found that a high level of management commitment increased safety compliance behaviors and decreased injury rates. Our study includes an organizational-level control variable that measures how senior-level fire officers' commitment to safety issues can affect the generic safety climate.

Research Method

Sample

The sample of respondents was comprised of 105 career firefighters in service to a Swedish city of roughly 110,000 citizens. Our respondents included 77 firefighters, 14 squad-leaders, 10 internal/external incident commanders, and four fire engineers. Only three of the participants were women.

The response rate was extremely high; over 95% of the department members responded to the survey. The questionnaire content was developed in cooperation with members of the fire department, and the questionnaire was distributed through the department's digital internal communication system. Responses were collected over a three-week period in May 2020. We followed accepted ethical guidelines for survey research. Participation was voluntary, and no personal information capable of identifying individual participants (e.g., years of service, age, and service location) was collected.

Measurement of Dependent and Independent Variables

The three dependent variables (safety climate outcomes) were (a) compliance with safety regulations, (b) frequency of generally unsafe behaviors, and (c) frequency of errors and mistakes. Firefighter safety compliance behavior was measured with a subscale (α =.72) from the Fire Service Safety Climate Scale (Taylor et al., 2019). This scale contained four items:

1. *"I wear my self-contained breathing apparatus at all times while engaged in a firefight, including during overhaul, until the environment is declared safe by an officer."*
2. *"I routinely ensure that my personal protective equipment (gear) is clean, especially after a fire."*
3. *"I routinely wash my protective hood."*
4. *"I shower and change my clothes immediately after returning to quarters from a fire."*

The frequency of generally unsafe behaviors was measured with a nine-item scale (α =.93) based on prompts from the Offshore Safety Questionnaire (OSQ) used in safety studies of the offshore oil and gas industry by Mearns et al. (2003):

1. *"I ignore safety regulations to get the job done."*
2. *"I break formal work procedures."*
3. *"I take chances to get a job done."*
4. *"I bend rules to reach goals."*
5. *"Work functions better if I ignore certain rules."*
6. *"Conditions at the workplace hinder me from following rules at work."*
7. *"I take shortcuts in my work that implicate small or no risks."*
8. *"I do not adhere to work rules when under pressure."*
9. *"Due to the management, I feel pressured to break rules."*

The frequency of mistakes/errors was measured with a single response item: "*I make errors and mistakes during incidents.*" This prompt was previously used in safety studies of the offshore oil and gas industry (Mearns et al., 2003).

Table 1 provides the descriptive statistics for the three dependent variables.

Table 1

Descriptive Statistics for Three Safety Climate Dependent Variables

Dependent variables	Min	Max	M	SD
DV 1: Compliance with safety regulations	2.25	5.00	4.02	0.61
DV 2: Frequency of generally unsafe behaviors	1.00	3.11	1.97	0.43
DV 3: Frequency of errors and mistakes	1.00	4.00	2.62	0.50

Note. Responses to the first dependent variable (DV 1) were rated using a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). Responses for the second (DV 2) and third (DV 3) dependent variables were rated using a 5-point Likert scale (1 = *never/almost never* to 5 = *very often/always*).

The four individual-level independent variables were (a) personal risk taking, (b) identity as a firefighter, (c) emotional exhaustion, and (d) work pressure. We measured firefighter risk taking with the following four response items (α =.70):

1. *"I enjoy taking risks."*
2. *"If the gain is high, it does not bother me to take risks."*
3. *"If there are other alternatives, I rarely or never take any risks" (inverted).*
4. *"I value safety in all aspects of my life" (inverted).*

A four-item scale (α =.86) presented by Postmes et al. (2013) was employed to measure the respondents' identity as a firefighter:

1. *"I feel close to firefighters as a group."*
2. *"I identify with firefighters as a group."*
3. *"I have much in common with firefighters as a group."*
4. *"Firefighters as a group are like a 'family' for me."*

One item was used to assess emotional exhaustion. The measure is a modification of an item derived from the "burnout subscale" found in the Fire Service Safety Climate Scale (Taylor et al., 2019). The prompt asks firefighters to rate their agreement with the statement, "*I feel emotionally drained from my work in the fire-service.*"

Finally, the effects of work pressure were controlled for with a five-item scale (α =.60) developed by Mearns et al. (2003). The prompts were:

1. *"Low manning levels sometimes result in rules being broken to get the job done."*
2. *"If I didn´t take risks, the job wouldn't get done."*
3. *"Sometimes it is necessary to ignore safety."*
4. *"Whenever I see safety regulations being broken, I point it out on the spot."*
5. *"There is never any pressure to put production before safety."*

The three work-group level factors were (a) group cohesion, (b) supervisor support, and (c) supervisor competence. Group cohesion was based on a nine-item scale (α =.93) from Smith et al. (2019b) with the following prompts:

1. *"Firefighters trust each other within my company."*
2. *"Firefighters within my company care about each other."*
3. *"Officers and firefighters within my company train well together."*
4. *"Firefighters trust each other in the squad."*
5. *"Firefighters within my company work together to get the job done."*
6. *"Firefighters within the company pull together to perform as a team."*
7. *"Officers and firefighters within my company care about one another."*
8. *"Officers within my company have the skills and abilities to lead firefighters on the fireground and in other emergency situations."*
9. *"Firefighters within my company can get help from their company officers on personal problems."*

Supervisor support was based on a subscale (α =.78) from the Fire Service Safety Climate Scale (Taylor et al., 2019). The scale contained seven items that focused primarily on support from leadership:

1. *"Our direct supervisor prioritizes rest and rehabilitation on scene."*
2. *"My direct supervisor puts a high emphasis on safety training."*
3. *"I have confidence in my command/my company officers to keep me safe."*
4. *"In our firehouse, we talk about safety on a consistent basis."*
5. *"Our firehouse does a good job of carrying out its safety policies."*
6. *"On our crew, people expect one another to wear their PPE."*
7. *"My direct supervisor takes my safety conditions seriously."*

Supervisor competence was measured with four items (α =.75) from the scale developed by Mearns et al. (2003):

1. *"My supervisor is reluctant to take the blame for his/her errors" (inverted).*
2. *"My supervisor has good people skills."*
3. *"My supervisor would approve of me taking shortcuts to get a job done quickly" (inverted).*
4. *"I trust my supervisor."*

Only one independent variable was used to assess the organizational-level influence on safety climate outcomes. The general safety climate variable was measured with the Generic Safety Climate Scale from the Fire Service Safety Climate Scale (Taylor et al., 2019). It contained five items (α =.88) that measured the employees' opinions toward the general safety climate of the organization. For translation purposes, in our questionnaire we used the term "top management" instead of "decision makers" shown in the five prompts below:

1. *"The decision makers in this department react quickly to solve the problems when told about safety hazards."*
2. *"The decision makers in this department try to continually improve safety levels in this department."*
3. *"The decision makers in this department invest a lot of time and money in safety training for members."*
4. *"The decision makers in this department try to reduce risk levels as much as possible."*
5. *"The decision makers in this department listen carefully to members' ideas about improving safety."*

Table 2 provides the descriptive statistics for the eight independent variables.

Table 2

Descriptive Statistics for Eight Independent Variables by Level of Influence

Independent variables	Min	Max	M	SD
Individual level				
Risk taking	1.00	4.00	2.53	0.61
Identity as a firefighter	2.00	5.00	3.86	0.62
Emotional exhaustion	1.00	4.00	2.10	0.90
Work pressure	1.40	4.60	2.85	0.63
Work-group level				
Group cohesion	2.88	5.00	4.29	0.55
Supervisor support	2.43	5.00	3.87	0.47
Supervisor competence	2.00	5.00	3.92	0.64
Organizational level				
Generic safety climate	1.00	4.80	3.24	0.69

Note. Responses to all independent variables were rated using a 5-point Likert scale ranging from 1 = *Do not agree at all* to 5 = *Agree totally.*

Hierarchical Estimation

To investigate the effects of the eight independent variables on our three safety climate outcomes, we used a hierarchical multiple regression strategy that considers three levels of potential effects. The individual-level factors were entered in the initial block, followed by the work-group level factors and the organizational-level control. The estimation results provide information about (a) the independent variables that significantly affect our safety climate outcomes and (b) the relative contribution(s) of individual, work-group, and organizational variables.

Prior to the estimation, we conducted an analysis of multicollinearity between our independent variables. No substantive issues emerged, and all correlations were within traditional bounds for multiple regression. To assess potential issues with the skewness of our variables, we also conducted an analysis using rank-ordered dependent variables. This procedure revealed small changes in β-values but did not affect prevailing significance levels.

Findings

Table 3 shows the results of the hierarchical regression analysis for each of the three safety climate outcomes (dependent variables): (a) compliance with safety regulations, (b) frequency of generally unsafe behaviors, and (c) frequency of errors and mistakes. For each safety climate outcome measure, we begin with an analysis of the independent variables that are significantly related to our dependent variables. This information is provided in the fully specified regression models for the three dependent variables shown in Block III of Table 3. Next, we discuss the relative contributions made by each of the three levels of theoretically defined influence—individual, work-group, and organizational—on each dependent variable shown in Blocks I, II, and III.

Predictors of Dependent Variable 1 (DV 1): Compliance with Safety Regulations

The regression model labelled Block III at the bottom of the left-hand column in Table 3 shows that three of our eight independent variables are significant predictors of the first safety climate outcome measure: compliance with safety regulations. The first significant variable is “identity as a firefighter,” an individual-level factor. The .32 regression coefficient for this variable is positive and significant at the .01 level. This finding supports previous studies (van Knippenberg, 2000) on the positive effect of social identity on safety behaviors. The remaining individual-level factors (i.e., personal risk taking, emotional exhaustion, and work pressure) were statistically insignificant.

Table 3
Hierarchical Multiple Regression Estimates of Self-Reported Safety Climate Outcomes

	DV 1 Compliance with safety regulations	DV 2 Frequency of generally unsafe behaviors	DV 3 Frequency of errors and mistakes
Block I – Individual level	(β)	(β)	(β)
Personal risk taking	-.10	.20*	.18
Identity as a firefighter	.48**	-.08	.00
Emotional exhaustion	-.15	.00	.25*
Work pressure	-.04	.48**	.05
R^2	.326	.355	.108
F	11.25**	12.79**	2.82*
Block II – Work-group level			
Personal risk taking	-.04	.22*	.20
Identity as a firefighter	.34**	-.08	-.03
Emotional exhaustion	-.04	.04	.28*
Work pressure	-.10	.53**	.02
Group cohesion	.28**	.16	.14
Supervisor support	.33**	-.08	.03
Supervisor competence	-.21*	-.04	-.08
R^2	.462	.372	.123
ΔR^2	.136	.017	.015
ΔF	7.60**	.49	.69
Block III – Organizational level			
Personal risk taking	-.04	.22*	.20
Identity as a firefighter	.32**	-.07	-.03
Emotional exhaustion	-.05	.04	.24*
Work pressure	-.14	.47**	.01
Group cohesion	.26*	.17	.14
Supervisor support	.38**	-.11	.05
Supervisor competence	-.17	-.06	-.07
Generic safety climate	-.11	.06	-.03
R^2	.469	.374	.124
ΔR^2	.007	.002	.001
ΔF	0.29	.63	.81

Note. * p < .05; ** p < .01; *** p < .001 [with 2-tailed test].

At the work-group level, we hypothesized that three variables—group cohesion, supervisor support, and supervisor competence—would all be predictors of increased compliance with safety regulations. Block III in the left-hand column of Table 3 shows this hypothesis was partially supported. Higher levels of group cohesion (β = .26) and supervisor support (β = .38) were significant predictors of compliance with safety regulations among our sample of firefighters. Group cohesion was significant at the .05 level, and supervisor support was significant at the .01 level. These results support previous findings about the positive effect of group cohesion and supervisor support on safety behaviors among firefighters (see Smith et al., 2019b; Taylor et al., 2019; Smith & DeJoy, 2014).

Supervisor competency as a group-level variable was not a significant predictor of compliance with safety regulations; neither was generic safety culture, the only organizational-level independent variable. The model as a whole explains 47% of the variance in this first dependent variable.

As noted previously, hierarchical regression analysis also allows for effects of theoretically specified types of variables to be determined. The left hand column of Table 3 shows that 33% of the variation in the first dependent variable can be attributed to Block I individual factors and, more specifically, to the "identity as a firefighter" variable. Two work-group level influences, group cohesion and supervisor support, explained 13% of the total variation (see ΔR^2, Block II Work-group level, left-hand column). The organizational-level variable "generic safety climate" did not add any explained variance.

Predictors of Dependent Variable 2 (DV 2): Frequency of Generally Unsafe Behaviors

The regression model labelled Block III at the bottom of the middle column in Table 3 shows that two of the eight independent variables are significantly related to our second safety climate outcome measure: frequency of generally unsafe behaviors. As we suspected, two individual-level variables—personal risk taking (β = .22, $p < .05$) and work pressure (β = .47, p = < .01)—predicted a greater frequency of generally unsafe behaviors among the firefighters in the sample. The other two individual-level variables (identity as a firefighter and work pressure), three group-level variables (group cohesion, supervisor support, and supervisor competence), and our single organizational-level variable (generic safety) were not significantly associated with generally unsafe behaviors.

The R^2 and ΔR^2 values shown in the middle column in Table 3 suggested that firefighters' reports on the frequency of unsafe behaviors in the fire department were mostly a function of two individual-level influences: personal risk taking and work pressure ($R^2 = .36$). The inclusion of the controls for work-group and organizational influences only increased the R^2 from .36% to .37% of the explained variance in this second dependent variable.

Predictors of Dependent Variable 3 (DV 3): Frequency of Errors and Mistakes

The regression model labelled Block III at the bottom of the right-hand column in Table 3 shows that only one of our eight independent variables is significantly related to the third safety climate outcome measure: frequency of errors and mistakes. As we suspected, firefighters in the sample responded that the individual-level "emotional exhaustion" variable (β = .24, $p < .05$) is a significant predictor of the greater frequency of mistakes and errors among the firefighters in the sample. The finding concurs with previous studies about the detrimental impact of emotional exhaustion and burnout on safety climate outcomes (Smith et al., 2018; Nahrgang et al., 2010).

Of the other individual-level factors (personal risk taking, identity as a firefighter, and work pressure), only personal risk taking with a β of .20 approached the threshold for a positive effect ($p < .06$). Variables in the work-group level (group cohesion, supervisor support, supervisor competence) and organizational level (generic safety) were not significantly associated with the frequency of errors and mistakes among firefighters.

Of the three dependent variables shown in Table 3, the variation in firefighters' reports of errors and mistakes was the least successful estimation. The regression equation had only one significant predictor: the individual-level "emotional exhaustion" variable. This predictor explained only 12% of the variation in the dependent variable compared to 47% and 37% for dependent variables 1 and 2, respectively. This finding is likely a function of the hesitancy of respondents to report mistakes, even though their responses were anonymous. The descriptive statistics for the three dependent variables (see Table 1) did not yield striking differences in the range or deviation, so the lack of predictive power in this last model may also have more complex origins.

Discussion

A number of studies have shown the importance of a positive safety climate in firefighting (Smith & DeJoy, 2014; Maglio et al., 2016; DeJoy et al., 2017; Smith et al., 2019b; Taylor et al., 2019). Our study builds on the extant literature by showing the impact that individual, work-group, and organizational factors have on three safety climate outcomes for career firefighters in one mid-sized Swedish city. While the findings reported here are instructive, more research is needed to understand the importance of these factors in a firefighting context.

For example, personality research suggests that impulsivity is a trait that could predict risk behaviors. Impulsivity is frequently associated with a lack of personal restraint (i.e., a low level of self-control) and a personal disregard of future consequences. A trait of sensation-seeking is also related to risk behaviors that elicit emotional arousal/excitement (Lauriola & Weller, 2018). In this study, we found that personal risk taking was significantly associated with a greater frequency of generally unsafe behaviors in firefighting.

Further research is necessary to understand the reasons why firefighters experience high levels of work stress. Our data showed that work stress was significantly related to a higher frequency of generally unsafe behaviors in our sample of firefighters. Experimental research outside the domain of firefighting suggests that time pressure increases risk taking when decision makers feel they can gain, rather than lose, something (Young et al., 2012). The mission of the fire service—to save life and property—may be considered a gain which, in turn, should increase risk taking.

This perspective could also explain the PPE noncompliance studied by Maglio et al. (2016) in their discussion of goal seduction. Using PPE may be seen as an obstacle to accomplishing the mission, especially when there is a time constraint for doing so.

The relationship between personal risk taking and work pressure also merits further attention. For example, data suggests that some firefighters are motivated to increase personal risks when an emergency situation involves children (Fender, 2003).

Research on U.S. firefighters also shows a relationship between work stress and emotional exhaustion/burnout (Smith et al., 2019a). More studies are needed to accurately identify which stressors in the work environment are causing these problems for firefighters (see Leiter & Maslach, 2003).

Findings reported in our study show the significant and positive impact that work-group level influences, such as group cohesion and supervisor support, have on compliance with safety regulations. These findings are similar to those reported by Smith et al. (2019b). Group cohesion is influenced by social factors such as firefighters sharing time and experiences together. They create a familiarity and a personal bond that increase social cohesion, which in turn leads to a higher compliance with safety behaviors.

When it comes to firefighters receiving support from their supervisors, research stresses the importance of a constructive and caring leadership style in the fire service. For example, Smith et al. (2020) argue that a safety-specific transformational leadership style is related to increased use of PPE and higher safety motivation among firefighters. Both of these results—higher safety motivation and increased use of PPE—lead to positive safety climate perceptions and safety behaviors (Smith et al., 2019b; Eldridge & DeJoy, 2016). This leadership style also promotes employee engagement and improves retention among volunteer firefighters (Mayr, 2017).

Supervisor support can also enhance trust in an organization. Fender (2003) argues that reciprocal trust between firefighters and leaders helps to prevent risk taking in the fire service.

Study Limitations

This study is limited in three ways. First, this is an exploratory study that uses survey data from a single fire service organization in Sweden. For generalizability, these results must be compared with studies performed in other fire service organizations across Sweden and in other countries.

Secondly, further research is required to understand why "generic safety climate," our only organizational-level independent variable, lacks any significant explanatory power. One possible reason is that we measured too few aspects of this complex concept. Management commitment was the primary focus of the measurement scale used in our study. Todd et al. (2019) has found that safety programs and policies, perceived fairness in the organization, and incident command are important measures that affect safety climate at the organizational level. The model advanced by DeJoy et al. (2017) included variables such as politics, organizational resources, and hiring and promotion policies.

In short, it seems that we underspecified the generic safety culture variable. To gain further insight into the measurement of this independent variable, our future research will use focus groups to gain a better understanding of the questions to include in our survey and apply a mixed-methods approach.

It is important to note that two of the three dependent variables—generally unsafe behaviors and frequency of errors/mistakes—were specifically developed for the offshore gas and oil industry. Our questionnaire may not have captured the essence of these safety outcomes in a firefighting context. Future studies should endeavor to develop specific safety climate outcome measures for firefighters. This process will require a qualitative understanding of what it means when firefighters bend rules or take shortcuts in the line-of-duty.

Conclusions and Practical Implications of Research

The findings of this study showed that identity as a firefighter, group cohesion, and supervisor support were all predictors of a higher compliance with safety regulations. Increases in personal risk taking and work pressure predicted an increase in the frequency of self-reported, generally unsafe behaviors. A higher level of emotional exhaustion predicted an increase in the frequency of self-reported errors and mistakes.

These results show that both interpersonal and intrapersonal factors influence firefighting safety climate outcomes. We recommend more efforts be made to understand personal risk taking in firefighting and how risk behaviors interact with work pressures in the line-of-duty.

These findings also highlight the importance of leader-governed work and a supportive and caring leadership style to fostering group cohesion in the fire service. We suggest that special attention be given to recruiting and training fire service leaders with these skills. We also support the recommendation that transformational leadership strategies be incorporated by the fire service to motivate safety compliance (Smith et al., 2020).

Further research is needed to evaluate how personal risk taking relates to task effectiveness in the line-of-duty. Taking risks is part of firefighting, but there is a critical point when risk taking can interfere with safety procedures and become a problem for both the firefighter and the organization. Developing and using a system of expert-guided observations could help to identify harmful risk-takers during training (Corey et al., 2018). Optimizing the fire service command structure could also motivate firefighters to avoid taking unnecessary risks (Fender, 2003).

Finally, it is important to identify all pressure-causing elements in the work environment of firefighters. As noted in the findings, work pressure and personal risk taking were the two variables that positively and significantly predicted the self-reported frequency of generally unsafe behaviors. According to the Swedish firefighters who participated in our study, work pressure increases the frequency of generally unsafe behaviors and diminishes the safety climate of the department.

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All *Fireground News* articles are editor invited and offer information relevant to the well-being, safety, and/or professionalization of the fire service. Most articles are based on research originally presented at the *International Fire Service Journal of Leadership and Management (IFSJLM)* Research Symposium (RS). This annual event is held in July at the International Fire Service Training Association (IFSTA) Validation Conference. As Founding Editor of the *IFSJLM*, on occasion I also invite authors to write about current issues or concerns that affect firefighters and EMS personnel. The invited article below focuses on the impact of COVID-19 on heart health, which carries implications for firefighters.

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The Perfect Storm: Firefighting, Cardiovascular Health Risk, and COVID-19

Abstract

Cardiovascular events continue to be the leading cause of acute, on-duty deaths for firefighters. Conducted in a hazardous environment, firefighting imposes a unique physiological strain on the body. The high cardiovascular strain of firefighting leads to increased risk for cardiac events, especially among individuals with underlying cardiovascular disease (CVD). The COVID-19 pandemic has added an additional concern about cardiac events in the fire service. Emerging evidence shows increased risk for cardiovascular conditions, even after acute infection has resolved. The fire service needs to be aware of this post-COVID-19 risk to avert unnecessary cardiac injury and fatalities.

Keywords: firefighter, firefighting, COVID-19, on-duty deaths, cardiovascular disease (CVD), Post-COVID Conditions, long COVID, dysrhythmias, heart health

Cardiovascular events have been the leading cause of acute firefighter line-of-duty deaths in most years since the National Fire Protection Association (NFPA) began reporting on these statistics. Exceptions were recorded in 2001 when 343 FDNY fire service personnel lost their lives on 9/11, and in the years 2020 and 2021 when 143 firefighter deaths from COVID-19 exceeded the 60 deaths attributed to cardiac events (Fahy & Petrillo, 2021, 2022). While the fire service is generally aware of the burden caused by cardiac-related fatalities, it may not fully appreciate the burden caused by cardiovascular disease (CVD).

Approximately 1,000 nonfatal cardiac events are reported while firefighters are on duty, and this number is likely much larger as not all injuries/events are reported (Campbell & Hall, 2022). Firefighters who have cardiac events off duty, or who require cardiac treatment for progressive disease, are not counted by any national reporting system. There is also a serious lack of information about the cardiac health of retirees. Undoubtedly, the actual burden of CVD in the fire service extends far beyond the well-known and concerning fact that cardiac events have accounted for over 40% of line-of-duty deaths over the past 10 years (Fahy & Petrillo, 2022).

The fire service has increasingly recognized the risk posed by CVD. For example, it has aggressively promoted policies to ensure firefighters receive annual occupational medical evaluations for early detection and treatment. The fire service has also worked to promote physical fitness programs that are key to prevention. Physical fitness programs lessen CVD risk factors and decrease the risk of cardiovascular and all-cause mortality. Other programs recognize the benefits of a comprehensive wellness approach on the cardiovascular health of firefighters. Despite these efforts, the rates of CVD (and sudden cardiac line-of-duty deaths) have remained stubbornly high. This article addresses the growing concern that latent effects of COVID-19 on cardiac health may compound the CVD risk that firefighters already face.

In May 2023, the president declared an end to the COVID-19 national emergency and, for most, there is certainly an eagerness to leave the pandemic behind. Unfortunately, millions of people have long-term health impacts and persistent symptoms from infection with SARS-CoV-2 (the virus that causes COVID-19). Post-Acute Sequalae of COVID (PASC), Post-COVID Conditions, or Long COVID are terms used to describe a variety of troublesome and sometimes debilitating health issues that linger or emerge weeks to months after the acute infection has resolved (Centers for Disease Control and Prevention, 2022). Since 2022, the umbrella term "Post-COVID Conditions" has been used by many to refer to a wide range of physical and mental health symptoms/conditions that are present four or more weeks following infection with the SARS-CoV-2 virus.

Further complicating matters is the reality that some Post-COVID Conditions, such as heart arrhythmias, may not be attributed to COVID-19 when they actually should be. Additionally, some of the cardiac conditions occurring do not have obvious symptoms that signal a problem to the individual.

Post-COVID Conditions can wreak havoc on virtually every body system. Given the burden posed by CVD and cardiac events in the fire service, the pronounced impact of COVID-19 on the cardiovascular system is of particular concern for firefighters.

Cardiovascular Strain of Firefighting

Firefighters face profound physiological changes due to the strenuous nature of their work, which is often conducted in a hostile environment. The metabolic work, thermal strain, and sympathetic nervous system activation associated with emergency work all contribute to significant cardiovascular strain. Firefighting leads to near maximum heart rates, increased cardiac work, decreased stroke volume, increased blood velocity, changes in blood vessel diameter and stiffness, and an increased clotting potential (Smith, 2016; Smith, et al., 2016). The cardiovascular strain of firefighting can trigger a cardiovascular event in individuals with underlying conditions, especially those with atherosclerotic CVD and a structurally enlarged heart (Smith et al., 2014; Smith et al., 2018; Soteriades et al., 2011).

Ideally, firefighters would maintain a high level of cardiorespiratory fitness and minimize CVD risk factors to lessen the risk of cardiac events. Unfortunately, that is not always the case. Research shows that CVD risk factors are highly prevalent among firefighters (Bode et al., 2021; Smith et al., 2020). For example, over two-thirds (69%) of the firefighters in a recent, large-scale study either reported hypertension or blood pressure values above current guidelines (Khaja et al., 2021). More than one-third of the participating firefighters in other studies were obese (Poston et al., 2011; Smith et al., 2020). The physically demanding and stressful nature of firefighting in individuals with underlying CVD (known or unknown) increases the risk of cardiac-related firefighter fatalities.

Physiology of COVID-19 and CVD

COVID-19 was initially considered a respiratory illness, but it quickly became apparent that the virus affected multiple organ systems. In fact, many COVID-19 deaths were related to cardiac events or excessive blood clotting. Now that acute infections are decreasing and the current variants appear less lethal, it is tempting to assume that COVID-19 is behind us. The evidence, however, paints a different and much more concerning picture.

Data now show there is an elevated risk of cardiovascular conditions long after the acute infection has resolved (Devries et al., 2023; Parhizgar et al., 2023; Shrestha et al., 2023; Wang et al., 2022; Xie et al., 2022). Post-COVID-19 cardiovascular complications, many of which can go undetected, may contribute significantly to an already high number of cardiac incidents (fatal and nonfatal) in the fire service. Although post-COVID-19 cardiovascular complications are more prevalent among individuals who have suffered a severe acute infection, an elevated risk of complications has also been reported in those who experienced mild-to-moderate illness (Wang et al., 2022; Xie et al., 2022). These findings are alarming given that over 70% of Americans have had COVID-19, and the situation presents a particular challenge for the fire service (Jones et al., 2023).

How the SARS-CoV-2 virus impairs the cardiovascular and other systems is still under investigation, but certain mechanisms appear likely. During the acute infection stage, damage can occur due to direct viral toxicity and result in myocardial injury, damaging cells in the heart muscle (Chang et al., 2021; De & Bansal, 2023; Parhizgar et al., 2023; Raman et al., 2022; Tobler et al., 2022). Infection with SARS-CoV-2 also elicits an exaggerated immune response that can trigger significant and detrimental inflammation. This inflammation can lead to the post-COVID-19 symptoms that persist or emerge months after infection.

Long-term cardiovascular complications following COVID-19 are possible because the virus affects all components of the cardiovascular system: the heart muscle (including the electrical conduction system of the heart) and the blood vessels (including inflammation in vessel walls and blood clotting potential). Damage to these components results in a wide range of cardiovascular conditions that research now shows can manifest during the acute illness *and* long after the initial infection with COVID-19 (Devries et al., 2023; Parhizgar et al., 2023; Shrestha et al., 2023; Wang et al., 2022; Xie et al., 2022).

Long-Term Cardiovascular Complications of COVID-19

Emerging epidemiologic data support reason for concern about long-term, post-COVID cardiovascular health risks (Devries et al., 2023; Parhizgar et al., 2023; Shrestha et al., 2023; Wang et al., 2022; Xie et al., 2022). **Table 1 (p. 34)** presents data from one large-scale study that explored cardiovascular complications between a group of U.S. veterans (mostly male) who had contracted COVID-19 and a control group of their contemporaries with no evidence of COVID-19 (Xie et al., 2022). The veterans with COVID-19 were assessed 30 days after testing positive for the infection and up to 12 months later. Cardiovascular outcomes were analyzed based on the severity of the individual's initial COVID-19 infection and whether they were hospitalized. Unsurprisingly, the risk of cardiovascular complications was much higher in the hospitalized group than the non-hospitalized group. For example, inflammatory heart disease occurred five times more often among those hospitalized for COVID-19 than among those with no evidence of COVID-19 (hazard ratio of 5.72 = over a 5-fold increased risk).

Importantly, however, there was a surprising result: the risk for all veterans who had contracted COVID-19—even those who were not hospitalized during the illness—was elevated (hazard ratio of 1.50 = a 50% increased risk) above the control group. Considering that the vast majority of individuals with COVID-19 were not hospitalized during the pandemic, this elevated risk among the majority of the population (and among the fire service) suggests that a huge number of individuals are at increased risk of developing cardiac conditions for at least a year following a COVID-19 infection. As shown in Table 1, researchers found that the risk for cerebrovascular complications among those not hospitalized for COVID-19 increased by 30% (hazard ratio of 1.30 = 30% increased risk). The risk of dysrhythmia increased by 33%, and the risk of ischemic heart disease increased by 24%. The increase in post-COVID-19 risk remained up to 12 months after the initial infection. The significant increase in these two risk areas is especially concerning in the fire service because dysrhythmias and atherosclerotic disease are the underlying substrates that can lead to sudden cardiac arrest or myocardial infarction on the fireground (Smith et al., 2018; Smith et al., 2019).

The study by Xie et al. (2022) summarized in Table 1 is not the only research indicating an increased risk of cardiovascular conditions after the acute infection of COVID-19 has passed. Another large-scale study of longer-term cardiovascular complications by Wang et al. (2022) used a more diverse sample from US healthcare organizations. Like Xie et al., Wang et al. found an elevated risk for certain cardiovascular outcomes among individuals who had been infected with COVID-19 but were not hospitalized with the virus. CVD outcomes were assessed from 30 days to one year after a COVID-19 positive test. Among the individuals who were not hospitalized, the risk of thrombotic disorders such as pulmonary embolism (hazard ratio of 2.6) and deep vein thrombosis (hazard ratio of 1.5) were particularly high. The risk of arrhythmias such as tachycardia and bradycardia increased by over 40%, and the risk of a transient ischemic attack increased by almost 50%.

Importantly, this study by Wang et al. (2022), as well as one by Rezel-Potts et al. (2022), found the risk for many post-COVID cardiovascular complications decreases over time. That is, the risk is greatest during and shortly after an acute COVID-19 infection and decreases toward the baseline risk over the course of a year. However, data are still emerging. It appears that the risk of certain cardiovascular complications may continue as long as a year after an acute bout of COVID-19.

Table 1

Risk of Post-Acute COVID-19 Cardiovascular Complications for up to 12 Months in Those With COVID-19 Compared to Contemporary Controls by Hospitalization Status

Outcome	Hazard ratio (95% CI) Non-hospitalized n=131,612	Hospitalized n=16,760
Cerebrovascular	1.30 (1.22, 1.37)	2.92 (2.53, 3.37)
Stroke	1.23 (1.15, 1.32)	3.06 (2.60, 3.59)
TIA	1.35 (1.23, 1.47)	2.47 (1.95, 3.14)
Dysrhythmia	1.33 (1.29, 1.38)	3.89 (3.55, 4.27)
Atrial fibrillation	1.32 (1.26, 1.39)	3.94 (3.45, 4.51)
Sinus tachycardia	1.37 (1.28, 1.46)	5.03 (4.33, 5.83)
Sinus bradycardia	1.29 (1.22, 1.37)	2.82 (2.41, 3.28)
Ventricular arrhythmia	1.35 (1.25, 1.46)	3.90 (3.16, 4.81)
Atrial flutter	1.33 (1.20, 1.46)	3.53 (2.77, 4.49)
Inflammatory heart disease	1.50 (1.28, 1.76)	5.72 (4.02, 8.15)
Pericarditis	1.38 (1.17, 1.64)	5.34 (3.60, 7.91)
Myocarditis	3.47 (2.25, 5.35)	12.13 (7.22, 20.36)
Ischemic heart disease	1.24 (1.18, 1.31)	3.76 (3.24, 4.36)
Acute coronary disease	1.16 (1.08, 1.24)	3.94 (3.28, 4.72)
Myocardial infarction	1.08 (0.99, 1.18)	4.35 (3.41, 5.56)
Ischemic cardiomyopathy	1.17 (1.06, 1.30)	3.34 (2.34, 4.77)
Angina	1.40 (1.29, 1.50)	3.34 (2.72, 4.10)
Other cardiac disorders	1.37 (1.31, 1.43)	3.94 (3.52, 4.42)
Heart failure	1.37 (1.31, 1.44)	3.93 (3.50, 4.43)
Non-ischemic cardiomyopathy	1.31 (1.22, 1.41)	3.20 (2.65, 3.86)

Note. Data obtained from Xie et al. (2022). The statistics shown in parentheses are the lower limits and upper limits of the 95% confidence interval (CI) for each outcome. All hazard ratios shown in Table 1 fall within their respective 95% CI.

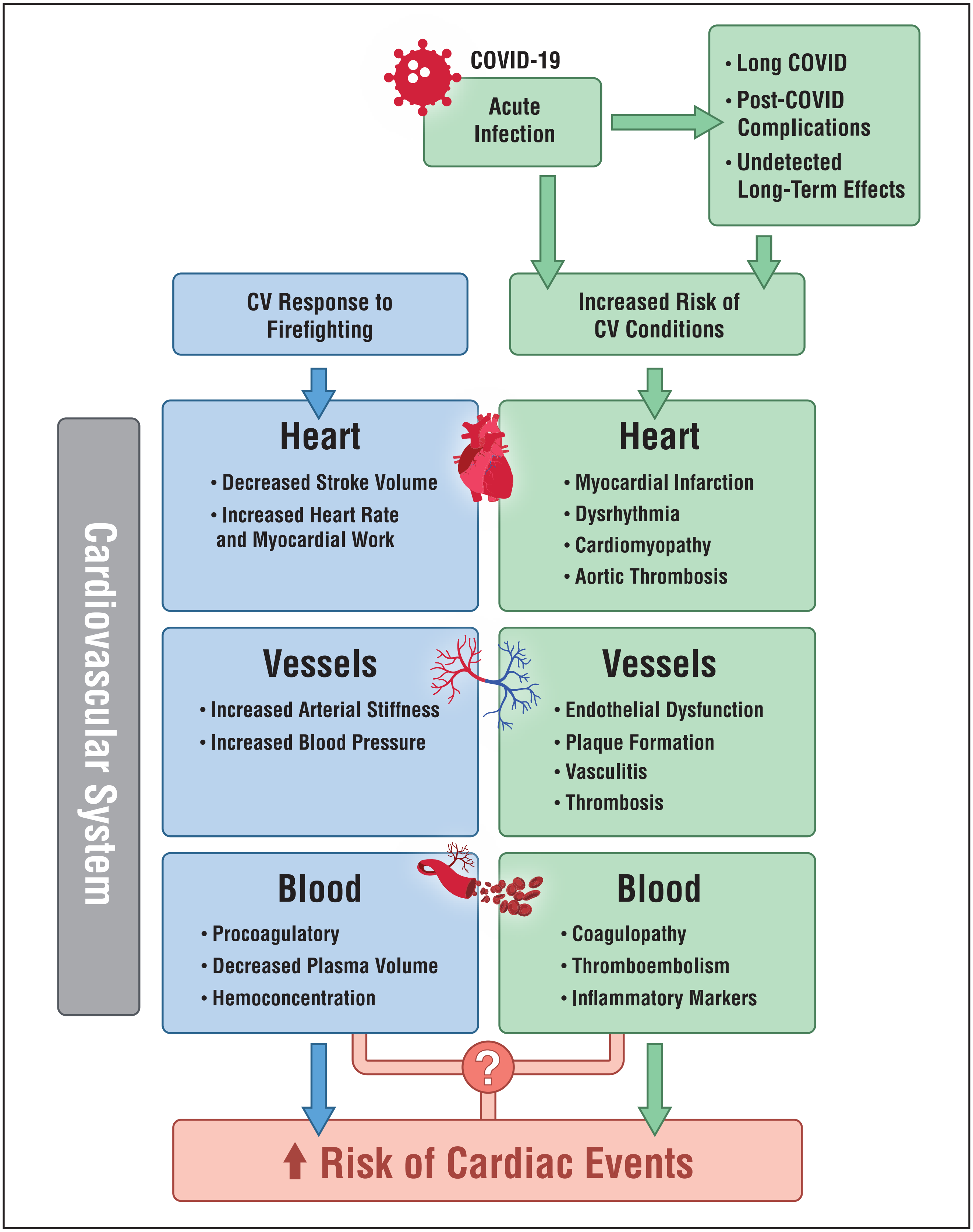
It is important to note that many of the early studies were conducted when the original COVID-19 variant was circulating, and often included individuals who were not vaccinated (because vaccines were not yet available). A great deal more needs to be learned about the long-term complications of the COVID-19 infection and the risk factors for those complications. Current evidence certainly suggests we should pay careful attention to the risk for post-COVID-19 cardiovascular conditions in the fire service.

Post-COVID Conditions Threaten to Compound Cardiovascular Risk in the Fire Service

As the left column of **Figure 1** shows, firefighting results in significant cardiovascular strain that affects all components of the cardiovascular system: the heart, the vessels, and the blood. The cardiovascular strain of firefighting can trigger a cardiac event, especially in vulnerable individuals who have structural changes to the myocardium (cardiomegaly or left ventricular hypertrophy) and/or coronary artery disease. As discussed in this article, COVID-19 can also cause significant longer-term cardiovascular complications. Both of these stresses on the cardiovascular system can lead to an increased risk of serious cardiac events among firefighters. However, the potential combined effect of firefighting *and* the long-term effects of COVID-19 on

Figure 1

Combined Risk of Cardiac Events Based on the Physiological Strain of Firefighting and Cardiovascular Conditions Post-COVID-19



Note. Firefighting is clearly associated with an increased cardiovascular strain that can trigger a cardiovascular event in vulnerable individuals. Current data indicate that, after infection with COVID-19, individuals have an increased risk of new or worsening CVD for up to a year after acute infection. The combined risk of firefighting and post-COVID-19 conditions is unknown.

the cardiovascular system (see note in Figure 1) has not been studied. This research gap is particularly concerning given what is known about the cardiovascular strain of firefighting and the risk following infection with COVID-19. Adding to the concern about the cardiovascular health of firefighters are data that indicate firefighters have a high prevalence of hypertension and obesity (Khaja et al., 2021; Moffatt et al., 2021), conditions that are associated with increased severity of COVID-19.

Conclusion

The fire service has played a critical role in responding to the COVID-19 pandemic. The fire service is also continuing to struggle with staffing shortages and budget constraints that are, in part, related to the pandemic. At this point, the vast majority of Americans, and certainly firefighters who were on the front lines during the intense early days of the pandemic without benefit of the vaccine, have been infected with SARS-CoV-2. Research has demonstrated convincingly that COVID-19 can impair or damage the cardiovascular system for at least 12 months after infection. Cardiovascular impairment and/or damage can occur whether COVID-19 symptoms are mild or severe, but the risk is greater after a more severe illness.

Given the high cardiovascular strain of their job, and the research documenting a high prevalence of cardiovascular risk factors, the potential for lingering effects of COVID-19 to further increase cardiovascular risk among firefighters is worrisome. Researchers are still learning about the long-term impacts of COVID-19 infection on the cardiovascular system, but it is critical that the fire service increase their situational awareness about this potential threat and remain vigilant about addressing new risks as they emerge.

The fire service can increase awareness by collaborating with occupational and allied health care providers. This collaboration can help to increase awareness of post-COVID-19 cardiovascular health problems that firefighters may or may not know they have. Careful attention to CVD risk factors is always warranted, but it is especially important in the post-COVID-19 pandemic era. Occupational medical evaluations are critical. If cardiac abnormalities are noted, COVID-19 illness should be suspected as a complicating factor, and occupational medicine providers should seek a cardiology consultation. Because occupational medical evaluations may fail to detect many Post-COVID-19 Conditions, firefighters and clinicians (occupational medicine providers, primary care providers, and allied health professionals) need to be aware of the potential long-term effects of the virus and work collaboratively to monitor and manage cardiovascular risk.

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