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Journal Team

Editorial Board

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IFSJLM would not be possible without the financial support of the College of Engineering, Architecture, and Technology and FPP. This support represents a commitment to the continued professionalization of the American fire service.

As a further indication of the support of FPP to the international fire community, all issues of the *IFSJLM*, except the two most recent years, are available for reading **free of cost** at the *Journal's* website. Please go to http://www.ifsjlm.org/PastEditions.htm to read and/or download previous issues of the *Journal*.

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and Fire & Emergency Services Consultant

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RESEARCH SYMPOSIUM 2019 (RS 19)

Dr. Gavin Horn

Research Engineer
UL Firefighter Safety Research Institute
Columbia, MD

RESEARCH SYMPOSIUM 2020 (RS 20)

No Recipient of the Dr. Granito Award
RS 20 Was Cancelled Due to Coronavirus

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 award honors Dr. John Granito.

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); Worcester Polytechnic/International Association of Fire Fighters/International Association of Fire Chiefs/ National Institute for Occupational Safety and Health *Fire Ground Performance Study*. John 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 in the top public universities by *U.S. News and World Report*.

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

Dr. Granito was the first recipient of the award that honors him and his service 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 following year's volume of the *International Fire Service Journal of Leadership and Management*.

Message from Dr. Robert E. England

Founding Editor, *International Fire Service Journal of Leadership and Management* (*IFSJLM*), Fire Protection Publications, Oklahoma State University

Welcome to Volume 14 of the *International Fire Service Journal of Leadership and Management*. Typically, readers should expect to see the annual volume released by the end of each calendar year.

We hope you enjoy Volume 14 of the *IFSJLM*.

Twelfth Annual Dr. John Granito Award for Excellence in Fire Leadership and Management Keynote Address presented at Research Symposium 2019 (RS 19) on July 13, 2019, by **Dr. Gavin Horn**, UL Firefighter Safety Research Institute, Columbia, MD and University of Illinois, Fire Service Institute, Urbana-Champaign, IL

Dr. Gavin P. Horn, UL Firefighter Safety Research Institute, Columbia, MD and University of Illinois, Fire Service Institute, Urbana-Champaign, IL
Dr. Steve Kerber, UL Firefighter Safety Research Institute, Columbia, MD
Dr. Kenneth W. Fent, National Institute for Occupational Safety and Health, Cincinnati, OH
Dr. Denise L. Smith, University of Illinois, Fire Service Institute, Urbana-Champaign, IL and Skidmore College, First Responder Health and Safety Laboratory, Saratoga Springs, NY

Management of Firefighters' Chemical & Cardiovascular Exposure Risks on the Fireground

Abstract

The fire service research community around the world has focused substantial resources on reducing firefighter risk for sudden cardiac events and chemical exposures that may lead to cancer. Research presented here summarizes important lessons learned from a full-scale residential Fireground Study that allowed quantification of the risks as well as the effectiveness of interventions to reduce those risks. To address fireground exposure concerns, personal protective equipment (PPE) and administrative controls exist. However, these controls are not always straightforward to apply. Leadership and management concerns with ongoing implementation of these controls are introduced and opportunities for change management are discussed. While research provides a solid basis upon which to institute policy and practice, fireground leadership and management is critical to ensure appropriate implementation.

Keywords: fire fighting, firefighter chemical exposures, sudden cardiac events, fireground risk mitigation, contamination control

Introduction

Leaders in the fire service are faced with an evolving landscape of local hazards to which they respond as well as the challenges that they need to manage on the fireground. To support fire departments, meaningful investments have been made in fire service research. Research on health and safety of firefighters has been driven by the evolving fireground, the fire service's deeper appreciation for individual health risks, and the availability of funding—including the notable efforts of the Federal Emergency Management Agency's Fire Prevention and Safety (FP&S) Grant program. Through these research efforts, important advances have been made in our understanding of the hazards associated with structural fire fighting (Kerber, 2012). As a result, the fire service has been provided with important tactical guidance to increase firefighter effectiveness while decreasing risk. At the same time, substantial evidence suggests that fire fighting leads to cardiovascular strain, and it is widely reported that firefighters also have an increased risk of developing certain job-related cancers. Through FP&S funding, efforts have been focused on studying these topics. However, these efforts will not result in improved health and safety without effective leadership and management to implement these findings.

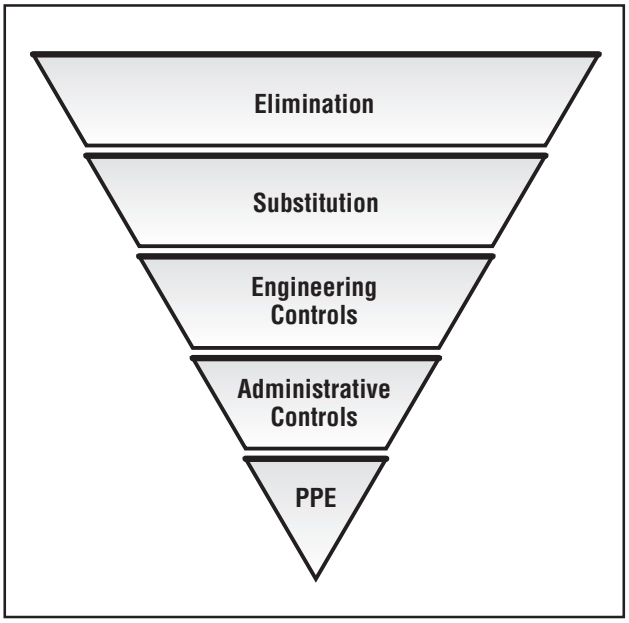
To begin, take a quick look at some statistics. Based on reporting from the National Fire Protection Association (NFPA) and the United States Fire Administration (USFA), it is well established that sudden cardiac events are one of the leading causes of duty-related deaths among firefighters (Fahy & Molis, 2019). Kales, Soteriades, Christophi, and Christiani (2007) estimated a 10–100 times increased risk for firefighters suffering sudden cardiac death after fire suppression compared to the risk associated with non-emergency duties. In 2019, Smith et al. (2019a) confirmed these estimations using autopsy data. These findings suggest that fire suppression activities may trigger sudden cardiac events in individuals with underlying heart disease.

During this same time frame, an increasing number of epidemiology studies have been conducted to determine the risk of cancer in the fire service. In a seminal effort, LeMasters et al. (2006) conducted a meta-analysis of several epidemiology studies from 1975–2003 and found an elevated risk for multiple types of cancer. In one of the largest cohort mortality studies ever conducted for firefighters, the National Institute for Occupational Safety and Health (NIOSH) found statistically significant mortality and incidence rates of all cancers, including cancers of the esophagus, intestine, lung, kidney, and oral cavity as well as mesothelioma for firefighters compared with the general population (Daniels et al., 2014; Pinkerton et al., 2020). The NIOSH team also found an exposure-response relationship for lung cancer as well as leukemia (Daniels et al., 2015). Studies conducted throughout the world have identified increased risks among firefighters for multiple types of cancer (Glass et al., 2014; Pukkala et al., 2009; Tsai et al., 2015).

There are a number of factors that can increase the risk of cancer. Some modifiable lifestyle risk factors include smoking, alcohol consumption, diet, obesity, and sun exposure as reviewed by Jahnke, Poston, Haddock, and Jitnarin (2017). Additionally, firefighters may be exposed to numerous carcinogenic compounds on the fireground, including benzene, certain polycyclic aromatic hydrocarbons (PAHs), formaldehyde, vinyl chloride, and other halogenated compounds. The three primary routes of exposure on the fireground include inhalation, ingestion, and dermal absorption. As products of combustion are emitted into the air from the fire source, one of the most direct routes for exposure of the firefighter is to breathe them in, which will allow absorption into the body through the respiratory system. Not only is this a direct route of exposure, but contaminants that make it to the lung are readily absorbed through the pulmonary capillaries directly into the bloodstream. Products of combustion may also end up on a firefighters' skin and be available for transdermal absorption. While the skin provides an excellent barrier to many chemicals, it is not impervious. The longer a chemical is present on the skin, the more time is available for transdermal absorption. Several important products of combustion can be absorbed through the skin directly in vapor or particulate form (Franz, 1984; VanRooij De Roos, Bodelier-Bade, & Jongeneelen, 1993). Finally, ingestion is possible by swallowing contaminants captured by mucous or the mucociliary ladder of the lungs or while ingesting food in a manner that allows transfer of contaminants from personal protective equipment (PPE) or hands onto food and into the digestive system.

NIOSH plays a leading role in identifying risks and protecting workers across all industrial sectors. The Hierarchy of Controls model shown in **Figure 1** defines five broad methods of protecting occupations from the hazards in the workplace, in order from the most effective (top) to the least effective (bottom). The fire service relies heavily on PPE due to the variability and often unknown conditions in the emergency response. As such, modern PPE is expected to protect the firefighter against environmental heat, water, and abrasion hazards; and now requirements are being added for protection against smoke ingress. It is important to remember that in addition to the protection it must provide, the PPE must still permit the firefighter to operate, conducting physically strenuous activities that require a high level of strength, muscle coordination, and/or endurance. Performing strenuous work in PPE results in metabolic heat generation that increases core body temperature and exacerbates cardiovascular strain.

Figure 1: Hierarchy of Controls



The purpose of this review is to provide fire service leaders with updated scientific information so they can be better informed on how to balance protection and risk that must be managed on the fireground.

Cardiovascular & Chemical Exposure Risks in Today's Fire Service

There has been great energy in the research community around the world focused on reducing firefighter risk for sudden cardiac events as well as risks for chemical exposures that may lead to cancer (Austin, Wang, Ecobichon, & Dussault, 2001; Bolstad-Johnson et al., 2000; Burgess et al., 2012; Fent et al., 2014; Hostler et al., 2014; Jankovic, Jones, Burkhart, & Noonan, 1991; Kales et al., 2007; Keir et al., 2017, 2020; Laitinen, Makela, Mikkola, & Huttu, 2012; Oliveira et al., 2020; Sjöström, Julander, Strandberg, Lewne, & Bigert, 2019; Smith et al., 2019a; Stec et al., 2018; Wingfors, Nyholm, Magnusson, & Wijkmark, 2018). This article will largely focus on lessons learned from a series of

studies led by the Illinois Fire Service Institute (IFSI), the UL Firefighter Safety Research Institute (FSRI), and NIOSH, with funding support from the FP&S Grant program. As the following information will focus on managing risk on the fireground, the bulk of this review will come from our Fireground Study, where teams of twelve firefighters responded to a ventilation limited fire involving 2 rooms in a full-scale residential-style test structure. Our work has resulted in many peer-reviewed scientific papers (Fent et al., 2017, 2018, 2020; Gainey et al., 2018; Horn et al., 2018; Kerber, Regan, Horn, Fent, & Smith, 2019; Smith et al., 2019b), which will be summarized in this review with a focus on leadership lessons. For this study, firefighters were assigned to fire attack, search and rescue, outside vent, overhaul, and command/pump operations and their job specific thermal and chemical exposures were quantified. The goal of this study was to better understand how operating in an environment typical of the early 21st century fireground impacts cardiovascular strain and chemical exposures related to carcinogenic risk. Additional insights have been gathered from subsequent studies, which have elucidated the contaminant pathways from the fire environment to the human body and the attenuation from the turnout gear.

Potential Respiratory Exposure on the Fireground

There are many risks for respiratory exposure while working at a residential structure fire. The most obvious threat is within the burning structure, which is why the fire service has expectations of SCBA usage for work in this location. However, risks are also present on the fireground outside of the structure and potentially from PPE **after** the firefight has ended, and too often we have failed to adequately protect firefighters when they are not in an *immediately dangerous to life and health* (IDLH) environment. Some major findings from our study include:

- ***Polycyclic Aromatic Hydrocarbons (PAH), Particulate, and Benzene During the Firefight***. The concentration of contaminants available for inhalation depends on the job assignment most closely associated with proximity to the fire itself. Firefighters assigned to attack and search job assignments are likely to have the highest median airborne PAH (17,800-23,800 µg/m^3) and benzene (37.9-40.3 ppm) exposures followed by overhaul (PAH: 512 µg/m^3, benzene: 0.9 ppm), outside vent (PAH: 96 µg/m^3, benzene: 0.2 ppm), then incident command/pump operator (PAH: <30 µg/m^3, benzene: <0.01 ppm) job assignments (Fent et al., 2018). However, the usage of SCBA trends in the opposite direction, reducing risk for the attack and search firefighters—but not protecting those who do not wear appropriate respiratory protection on the fireground.
- ***Airborne Measurements of Hydrogen Cyanide (HCN).*** The highest concentrations of hydrogen cyanide were measured in the area where the attack firefighters operated (median 33.5 ppm). However, as these firefighters were wearing SCBA during their activity, inhalation exposure was likely low. The next highest concentrations were measured at the outside vent position (Fent et al., 2018), where SCBA usage is not as consistent. The median personal air concentration of HCN for the outside vent firefighters (14 ppm) was well above the NIOSH short-term exposure limit (4.7 ppm), and occasionally exceeded IDLH limits (50 ppm).
- ***Gas Exposure During Overhaul.*** Anecdotally, firefighters may choose to doff their SCBA during overhaul. In our Fireground Study, we characterized the impact of unprotected overhaul exposure using a mouse model without airway protection while firefighters were conducting overhaul to assess risk to the lungs in the form of gene expression (Gainey et al., 2018). Although gas metering showed that the levels of gasses that are commonly monitored during overhaul were well below NIOSH ceiling limits, 3,852 lung genes were differentially expressed in the mice exposed to overhaul environment compared with mice on the fireground, indicating increased risk for those who conduct overhaul without airway protection.
- ***Particulate on the Fireground.*** Concentrations of particulate were by far the highest inside the structure during fire attack (median >1,000,000/cm^3). However, significant elevations of particulate concentrations were also measured outside of the structure near the attack engine (median >20,000/cm^3). Concentrations were the highest on the fireground when downwind of the structure with heavy ground-level smoke, but were also measurable when downwind of the structure with minimal ground-level smoke. It is important to note that diesel exhaust from the nearby apparatus also contributed particulate, gases, and vapors to the samples measured (Fent et al., 2018).
- ***Off-gassing Following Fire Fighting Activity.*** Even after the firefight has ended and the visual signs of inhalation risk have subsided, inhalation hazards may remain if contaminated PPE is not properly handled. During the firefight, PPE may absorb volatile compounds (e.g., benzene, HCN) that can then be released back to the air in areas that may not have originally been contaminated. One component of our Fireground Study investigated off-gas concentrations in a compartment the approximate size of an apparatus cab

and found that levels were well below applicable short-term exposure limits (e.g. benzene: 3,200 µg/m^3) (Fent et al., 2017). However, off gassing provides another potential route of exposure for those who may have already been exposed during the firefight.

Respiratory Exposure Control Measures

Fortunately, respiratory protection control measures are well known and in place in many fire departments. Positive-pressure self-contained breathing apparatus (SCBA) can essentially eliminate inhalation of these toxicants (Occupational Safety and Health Administration, 2011). Unfortunately, however, firefighters do not always wear SCBA, for example, when sizing up the fire, when working as the engineer or incident commander, or when conducting overhaul operations. Results of this study highlight the need for SCBA protection throughout the firefight as well as the importance of enforcing these policies during overhaul and outside vent operations. Furthermore, pump operators and incident commanders should consider respiratory protection when working in smoky conditions or when they may be exposed to diesel exhaust.

Additionally, secondary exposure to off-gassing may be reduced by allowing the PPE to air out outside of enclosures. The off-gas levels returned to near background concentrations after 17-36 minutes after our initial measurements for the majority of the volatile organic compounds (VOCs) (Fent et al., 2017). However, semi-volatile compounds would likely take much longer to volatilize and is an area of continuing research.

Potential Dermal Absorption Risks from the Fireground

While protecting the airway may be the most important control measure to implement on the fireground, it has become increasingly apparent that dermal absorption plays a key role in systemic exposure for firefighters. Skin exposure can occur during fire fighting by way of permeation or penetration of contaminants through the hood, turnout jacket, and trousers, in between interface regions of this ensemble, or through the cross-transfer of contaminants on gear to skin.

- In our Fireground Study, higher PAH biomarkers and benzene concentrations were found among firefighters assigned to fire attack and search operations than any other job assignment (Fent et al., 2020). This is a particularly important finding because the attack and search firefighters protected their airways during the fire response by using SCBA and were not allowed inside the structure without airway protection. Overhaul firefighters had significantly lower biomarkers of PAHs despite operating inside the structure (with SCBA) for longer periods of time than did the attack and search firefighters. Thus, the concentration of contaminants, and potentially elevated temperatures and increased pressure within the structure during the active firefight, may have resulted in increased concentrations of contaminants being absorbed by the skin. These findings reinforce previous reports that dermal absorption contributed to firefighters' systemic levels (Baxter, Hoffman, Knipp, Reponen, & Haynes, 2014; Fent et al., 2014; Keir et al., 2017).
- In several scenarios, contamination was found on the neck even when hoods designed to block particulate penetration were worn. In some cases, these qualitative patterns of contamination appeared to be related, in part, to the hood doffing process.

Dermal Absorption Control Measures

Current PPE designs have important, yet limited ability to fully protect against fireground products of combustion reaching the skin. Research and development activities are currently taking place to redesign PPE to further reduce chemical ingress through particle blocking hoods and tightening down PPE interfaces. The benefit of the changes still must be quantified. It is also important to study opportunities to implement administrative controls to reduce these absorption risks. By managing these administrative controls, the fire service may be able to affect a reduction in exposure even using current PPE.

- ***On Scene PPE Cleaning.*** Three types of decontamination methods were evaluated during the Fireground Study: 1) dry-brush decontamination with a stiff-bristled brush; 2) experimental air-based decontamination with modified leaf-blower; and 3) wet-soap decontamination with water and dish soap applied to the turnout gear, scrubbed with a brush, and then rinsed. The wet-soap method removed an average of 85% of surface PAH contamination (Fent et al., 2017). Dry brush decontamination removed about 25% of the contamination and the air-based decontamination had minimal impact. In a separate study, Calvillo et al. (2019) found that water only decontamination also had limited effectiveness, though important limitations are identified in their manuscript. We suspect that the surfactant in dish soap, which is designed to liberate fat-soluble compounds from surfaces, was important for removing PAHs.
- ***On Scene Skin Cleaning.*** Cleansing wipes were found to reduce PAH contamination on neck skin by a median of 54% (Fent et al., 2017). Not all cleansing wipes may have equal efficacy and further study is warranted into all means of on scene

skin cleansing. However, because ~50% of the contamination may remain on the skin after using cleansing wipes, showering, hand washing, and other means of more thorough cleaning of the skin should be conducted as soon as feasible.

- ***Implementing Contaminated Doffing Techniques.*** While firefighter PPE continues to improve, doffing PPE can result in secondary exposures to the same contaminants from which the firefighter was initially protected. Traditionally, firefighters are trained to doff their PPE by pulling their hood down around the neck to allow access to the facepiece straps. This approach results in exposing the neck to the contamination on the outside of the hood. Similarly, fire fighting gloves are often doffed in a manner that results in transfer of contaminants from the outside of the glove to the skin of the hand. By performing gear removal in a manner similar to hazmat or EMS PPE doffing where contact with the outer layer of the PPE is avoided, it may be possible to more carefully control where the contamination can contact the skin (Illinois Fire Service Institute, 2017, 2018). While not always feasible on the fireground, firefighters may consider this approach, particularly in the case where the firefight has ended and a firefighter is reporting to rehab. These techniques for contamination control can be integrated with a standardized process for cleaning the neck skin once the hood has been doffed.

- ***Suppression Technique.*** The process for selecting which suppression technique to employ on the fireground must first consider occupants of the structure—how to rapidly search and rescue those at risk with respect to the tenability for trapped occupants (Kerber et al., 2019). Secondary considerations may include how tactical choice impacts risk for compromising fire fighting PPE and how fireground operations may impact firefighter's chemical exposures. In our Fireground Study, the transitional attack (applying water to a fire from the exterior prior to entry) scenarios resulted in significantly lower ambient temperatures throughout the structure while firefighters were operating compared to the interior attack, but this did not translate to a significant reduction in firefighter's heat stress (Horn et al., 2018). However, urine measurements from these firefighters indicate that transitional attack resulted in 20% to 50% lower metabolite levels of certain PAHs compared to interior attack (Fent et al., 2020). Overall, our findings indicate that while there was no significant impact of tactic on heat stress, transitional attack could be implemented as an administrative control to reduce firefighters' exposures to PAHs when it is appropriate. *It must be stressed that selection of fire attack tactics must consider a broad range of factors in addition to firefighters' exposures*.

Cardiovascular and Thermal Risks from the Fireground

Fire fighting increases thermal and cardiovascular strain. In fact, the increase in body temperature exacerbates the increase in cardiovascular strain. We have documented significant increases in heart rate (near age-predicted maximum for fire attack, search, overhaul, and outside vent job assignment) and core temperature (mean increases of 1.8 F for fire attack and search and ~3.1 F for overhaul and outside vent activities) even during this short experiment in which firefighters worked with a 30 minute SCBA air cylinder.

Additionally, firefighters were assigned to unique responsibilities, (i.e. overhaul was done by a different crew than fire attack) such that each firefighter was fresh prior to their job assignment and core temperatures could increase to even higher levels if multiple bouts of activity are required. Furthermore, earlier studies that have shown convincingly that some of the cardiovascular changes, such as increased coagulatory markers or a decrease on cardiac blood flow could be mechanistically linked to sudden cardiac events. In this study, we found that five firefighters who had normal ECGs in a 12-hour control period developed indicators of myocardial ischemia following fire fighting (Smith et al., 2019b).

Cardiovascular and Thermal Risk Control Measures

Medical evaluations performed by a physician serve as the most important steps to ensure firefighters can endure the cardiovascular and thermal strains of the job. Those tests must be performed by a physician who understands the job's physiological and psychological stresses. Firefighters also need access to a wellness and fitness program to ensure they are fit enough to safely do the job.

On scene, leaders should consider the physical stress of the job and consider rotating crews or providing relief when possible. This may include having a fresh group of firefighters perform overhaul or repack the hosebed. In places where personnel are severely limited, it may mean having extended rehab time before performing overhaul, or even putting firefighters in lighter-weight protective clothing to perform overhaul.

One of the great balancing acts that leaders face is providing adequate protection against burn injuries and smoke exposure on one hand, and the increased cardiovascular and thermal strain that comes from using heavy, encapsulating gear on the other hand. Rehabilitation also provides an opportunity to evaluate firefighters to make sure they are recovering as expected.

Leadership & Management in Fireground Exposure Risk Reduction

Protecting the Airway

Many fire departments have policies for wearing SCBA during fire fighting operations, and it is a common expectation during interior fire fighting activities. However, more widespread challenges remain when firefighters are operating in other job assignments. In recent years, anecdotal evidence suggests an increase in SCBA usage during overhaul. While this decreases exposure risks, this use comes with a cost, namely, an increase in the metabolic cost of the work and a resulting increase in temperature and cardiovascular strain. Fireground leaders should account for the increased metabolic work necessary when conducting overhaul with SCBA compared with the same task without a SCBA. In the Fireground Study, we measured a mean increase in core temperature of ~3 °F while working through a single 30-minute SCBA cylinder in overhaul (Horn et al., 2018). Such an increase in core temperature may not be overly concerning for a rested firefighter. However, if that firefighter had just completed fire attack or outside vent, their core temperatures would already be elevated and this additional work may result in core temperatures that increase to dangerous levels. To support extended use of SCBA throughout overhaul, leadership should consider bringing additional personnel to the scene in order to reduce the thermal and cardiac strain on firefighters. Additional personnel on scene will allow fire attack firefighters (who may be heavily exposed to fireground contaminants) to more rapidly conduct decontamination/rehabilitation. Another approach that has been implemented in some jurisdictions is to conduct overhaul after rehabilitation in lighter weight wildland/hybrid PPE in an attempt to mitigate the thermal and cardiovascular exposure risks while providing the highest level of airway protection.

Enforcing airway protection for other job assignments will, in many places, require a change in culture and expectations. Outside vent firefighters will often wear SCBA when in heavy smoke, but gasses such as HCN may not be visible and may partition to upper levels differently than heavier products of combustion such as particulate and benzene. Additionally, while it is good practice to establish command and pump operations at locations upwind from the smoke plume, such locations are not always available. In such cases, airway protection can provide an increase in contamination control (Burgess et al., 2020) if policies and procedures are implemented to support this control measure. While these fireground concentrations are found to be much lower than inside the structure, they are an increase over background levels and another source of exposure near the fire building.

Relatively recent understanding of risks posed by PPE off gassing after the firefight has led to some changes in policy and in some cases updates in apparatus and station design. But in its simplest case, because of the potential off-gassing route of exposure, turnout gear could be left outdoors to off-gas and/or separated and isolated from occupied compartments of an apparatus (e.g. bagged and/or transported in an unoccupied compartment on the apparatus or other vehicle). Some departments have assigned gear transfer totes to their members to reduce this risk in personal and fire department vehicles.

Cleaning PPE

The Fireground Study provided the first quantification of the effectiveness of gross on-scene decontamination techniques (Fent et al., 2017). While the evidence of effectiveness is clear, implementation of the practice has sometimes been met with challenges, resistance, and questions. Some of this resistance may be attributed to varying beliefs and behaviors related to wet decontamination techniques, such as concerns over time limitations and the safety impacts of wet gear (Harrison et al., 2018a). Such barriers to implementing post fire decontamination may be overcome through targeted messaging (Harrison et al., 2018b); but can also be reduced through managing iterative enhancements in processes as this relatively new fireground function is tested, evaluated, and improved.

As with any fireground function, training is important to learn technique. It is suggested that, if adopted at a fire department, wet soap decontamination be included during live-fire training evolutions so it can be more efficiently and effectively implemented on the fireground. This practice will help firefighters know how to best apply water to minimize soaking the gear and the firefighter. Water application will depend on contamination level but should mostly be used to pre-wet the gear, then rinse off the soap solution. Anecdotally, excessive water has been used to remove large pieces of debris from the turnout gear, which can result in soaking the gear and increase possibility for wetting interfaces and skin. Consider balancing wet and dry methods when large pieces of debris are present. However, if dry methods are used, it is important to manage the potential exposures from contamination that becomes airborne. Those being deconned as well as those doing the decontamination, and anyone downwind of that location, should consider appropriate PPE from this airborne particulate.

Fireground officers will also need to manage the process of handling PPE after it is deconned on scene, particularly if it is wet. The 2020 Edition of the NFPA 1851 standard (National Fire Protection Association, 2020) contains a decision support tool that should be consulted. In addition, fire departments should consider department policies for handling gear wetted

by environmental conditions or hose overspray and enforce similar precautions that would be taken if the outer shell has been wetted by these sources.

Environmental extremes can present important challenges while conducting fireground decontamination, and leaders need to make appropriate decisions to balance the risks from contaminated gear with other environmental hazards. It is important to remember that on a hot summer day the firefighter inside their PPE waiting to be deconned may have just completed a long, intense bout (or bouts) of fire fighting activity and cannot cool down or recover from the thermal and cardiovascular stress of fire fighting as easily as if his or her PPE were removed. Similarly, a firefighter conducting decontamination in freezing conditions may be at increased risk for hypothermia and frostbite. Thus, it is important to balance the risk of heat stress or cold stress for the member with the risk for additional chemical exposure. One way to manage this balance is to address environmental stressors as part of integrated rehabilitation. The flow of personnel through decontamination should be managed by prioritizing firefighters based on availability of air and their physical and psychological stress levels. Establish multiple decontamination lines/stations to move firefighters through more rapidly when feasible. Provide hydration where feasible. In the cold, manage cold stress by providing warming stations for all those being decontaminated and those working in decontamination lines as quickly as possible. Manage risk for slips and falls by making ice melt available where decontamination is taking place. Deconning fire fighting PPE is an important risk reduction process but should be managed with the other risks that may be present on each fireground.

Cleaning Firefighter Skin

Leadership in the fire service should also consider implementing a skin cleansing program for every response or training scenario where products of combustion are present. By including skin cleaning as part of training, firefighters can develop the expectation that they are responsible for cleaning themselves after a bout of fire fighting activity. Similar to decontaminating PPE after training, this process can begin to build muscle memory in controlled conditions prior to deployment on the fireground. Wipes can be made available as soon as firefighters exit a burn structure and begin debrief as well as during bottle changes, at air fill stations, and before getting back on the apparatus. Making the wipes visible and company/command officers reminding firefighters to use them will reinforce this habit.

On the fireground, wipes should be made available near the command vehicle, staging areas, on forward located apparatus, and transition to rehabilitation. It may also be useful to provide a mirror at a few locations to help firefighters self-identify the presence of contamination. A small investment can go a long way in assisting firefighters to be efficient in their use of wipes and to be cognizant of the need to do so. Fireground leadership can support this awareness and implementation in best practices.

Contaminated PPE Doffing

Implementing contaminated doffing techniques on the fireground may appear a foreign and challenging proposition in many departments. While a great deal of time and effort has historically been spent teaching firefighters to quickly and effectively don their turnout gear, relatively little time is typically spent on the doffing process. On the other hand, training for medical responses (EMS) will often focus on donning PPE appropriately for body substance isolation, but also highlights the importance of doffing PPE, particularly gloves, appropriately. Likewise, hazmat responses require specialized PPE and a controlled and institutionalized decontamination and doffing process to ensure these hazardous materials are not transferred to the responder. Thus, many firefighters are familiar with the need for contaminated doffing methods, and the fire service has adopted these processes for specific responses.

Now is the time for leadership to consider implementing similar approaches for contaminated equipment doffing after fireground activities. An opportune time to develop, test, and implement these techniques is during training scenarios, either live-fire training at an academy or station-based training. The more these approaches are practiced, the more likely they will be performed correctly on the fireground.

Integrating Decontamination and Rehabilitation on the Fireground

Incident scene rehabilitation has evolved in the fire service and has become a common fireground activity in many departments. Thanks in part to the evolution of NFPA 1584, processes have become standardized and expected. With the increasing concerns related to firefighter hygiene and cleanliness, there is an opportunity to evolve rehabilitation to integrate decontamination – *from hygiene to hydration*. In this way, the on-scene decontamination, contaminated doffing, and skin cleaning processes become part of an established fireground tactic.

It is important that these hygiene steps take place prior to entering rehab where feasible. If contaminated gear is not cleaned and doffed, then contamination can easily spread to firefighters' skin as well as the equipment and personnel working in the rehab sector and then other firefighters. The potential for PPE off-gassing can further expose firefighters and support personnel as airway protection is not commonly worn in rehabilitation. Additionally, if hygiene practices are not appropriately managed, risk for ingestion of fireground

contaminants can increase while eating finger foods where transfer from hand-to-food-to-mouth is possible. To reduce this risk, skin cleaning wipes or sinks can be provided along with mirrors at the entry to rehab as a reminder to clean skin in order to reduce risk to the firefighter and rehab personnel.

Finally, rehab provides an important opportunity to reflect on the incident actions as an individual and group. This process is important for tactical debriefing, but also to immediately report exposures from the incident and assess if personnel are recovering appropriately. Exposure tracking—both chemical and emotional—has become an important component of a firefighter's personal activities after a fire. Several apps, such as National Fire Operations Reporting System (NFORS), have been developed to ease the reporting process. Leaders should consider encouraging personal responsibility in collecting this information, particularly during the initial recovery period allowed by incident scene rehabilitation. Furthermore, the time spent in rehabilitation can be used to ensure firefighters are appropriately recovering from the event. Those managing rehabilitation should be made aware of a firefighter not feeling well after strenuous activity in order to keep a close eye on the individual, in rehabilitation and after return to the station. Similarly, conversations within rehabilitation may provide the opportunity to identify personnel who are emotionally struggling with the events of the incident so that peers may be able to provide support and assistance.

Summary

As risks continue to evolve on the fireground, so too will research to assist the fire service in responding. We know more now about the type and magnitude of the risks that are faced than at any time in fire service history. However, we are still working to quantify how effective interventions might be as well as how to support fireground leaders and managers to implement these interventions. We have provided a summary of lessons learned from fireground studies as well as begun the discussion of challenges that must be overcome to implement effective interventions. For more resources related to this project, science, translation, and teaching tools can be downloaded free of charge from the on-line project toolkit (https://www.fsi.illinois.edu/CardioChemRisks/#!/) and through the UL FSRI Fire Safety Academy (https://training.ulfirefightersafety.org/) and website (https://ulfirefightersafety.org/). More will be learned and shared as the fire service and research community work through this process together.

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About the Authors

Gavin Horn is a Research Engineer with the UL Firefighter Safety Research Institute (FSRI). Prior to joining the UL FSRI team, he served as the Director of IFSI Research Programs at the University of Illinois Fire Service Institute (IFSI) for 15 years and as a firefighter, apparatus engineer, and fire investigator with the Savoy (IL) Fire Department. Gavin's research interests range from firefighter health and safety to first responder technology development. Dr. Horn serves as corresponding author and can be reached at: **Gavin.Horn@ul.org**

Steve Kerber is the Vice President of Research for Underwriters Laboratories Inc. and Director of the UL Firefighter Safety Research Institute. Steve has led research in the areas of fire safety engineering, firefighter safety, fire forensics, and fire science. Steve is also a 13-year veteran of the fire service, with most of his service at the College Park Fire Department in Prince George's County, Maryland, where he served at ranks up through Deputy Chief.

Kenny Fent is a research industrial hygienist and head of the National Firefighter Registry at the National Institute for Occupational Safety and Health (NIOSH). He has spent over a decade studying firefighters' exposures and health effects. Kenny has also published over 60 articles and reports summarizing his findings. He is also a Commander in the U.S. Public Health Service, where he has responded to domestic and international emergencies.

Denise Smith is a Professor of Health and Human Physiological Sciences at Skidmore College (NY) where she is director of the First Responder Health and Safety Lab. She is also a senior research scientist at the University of Illinois Fire Service Institute. She has published over 90 scientific papers with a focus on firefighter health and safety. She is a member of the NFPA 1500 committee and an investigator for the NIOSH firefighter fatality investigation and prevention program.

Chief Matthew Tobia, E.F.O., City of Harrisonburg (VA) Fire Department
Dr. Sara A. Jahnke, Center for Fire, Rescue & EMS Health Research, National Development and Research Institutes – USA
Chief Todd J. LeDuc, M.S., C.F.O., LifeScan Wellness Centers
Dr. Denise L. Smith, University of Illinois, Fire Service Institute, Urbana-Champaign, IL and Skidmore College, First Responder Health and Safety Laboratory, Saratoga Springs, NY

Occupational Medical Evaluations in the US Fire Service: State of the Art Review

Abstract

Firefighters face a broad range of health risks including the deleterious effects of shift work, exposure to carcinogens, strenuous activities, and significant exposures to trauma. As a result, there is evidence firefighters experience increased rates of cancer, behavioral health issues, and significant risk of duty-related cardiovascular events. Due to these risks and outcomes, there has been a growing discussion centered on the need for annual medical evaluations for all firefighters. This article provides a summary on the state of the science, barriers, and types of medical evaluations being delivered. Future directions and noted research needs are presented.

Keywords: annual medical evaluations for firefighters, firefighter health and wellness, firefighter line of duty deaths, firefighter physicals

Introduction

Year after year, sudden cardiac deaths account for more on-duty firefighter fatalities in the United States than burn injuries, asphyxiation, or being lost/trapped inside a burning structure. Scientists and national fire-related organizations have consistently asserted that one of the most important factors in decreasing these preventable line of duty deaths (LODDs) is to ensure that firefighters receive proper medical evaluations as candidates, and annually thereafter. However, limited systematic work has been done to describe the extent to which fire departments are providing medical evaluations for personnel or to detail the different models of delivering medical evaluations. This State of the Art Review on medical evaluations in the fire service will: (1) provide data on firefighter fatalities reported by different agencies; (2) synthesize available information regarding the percentage of firefighters receiving medical evaluations; (3) delineate major approaches for the provision of medical evaluations; (4) explore strategies that fire service leaders can employ to ensure that firefighters are receiving and benefiting from the most appropriate medical evaluations; and (5) make recommendations for additional research into positively impacting one of the most challenging obstacles to significantly reducing preventable line of duty deaths in the US fire service.

Line of Duty Fatality Statistics

Firefighter fatalities are a concern for fire chiefs, their departments, and for the communities firefighters serve. Somewhat surprisingly, counting line of duty fatalities is not without difficulty. Each year the National Fire Protection Association (NFPA), the United States Fire Administration (USFA), and the National Fallen Firefighters Foundation (NFFF) report deaths for all firefighters in the United States. However, the three entities report different counts for line of duty fatalities because each organization has distinct criteria for including firefighter deaths in their reporting. Divergent LODD counts do not reflect an inability or unwillingness of the entities to work cooperatively, rather the discrepancies reflect the diversity of the mission of each organization.

The NFFF criteria includes all firefighters who die in the line of duty while responding to, returning from, or operating on the scene of a call *and within 24 hours* of responding to a call for service, and participating in department-directed strenuous physical fitness activity or department-sanctioned training (regardless of whether any symptoms developed while on-duty) (National Fallen Firefighters Foundation, 2020). By contrast, the USFA requires that the firefighter had to have complained of symptoms prior to going off-duty if such death occurred while off-duty but within the 24-hour window (U.S. Fire Administration, 2018). The NFPA defines *on-duty* a bit differently, as “Illnesses (including heart attacks) are included when the exposure or onset of symptoms occurred during a specific incident or on-duty activity” (Fahy & Molis, 2019, p. 2).

Although nuanced, these definitions illuminate one of the reasons organizational numbers differ. Additionally, the NFFF changed its criteria beginning in 2018 to include firefighters who died as a result of occupational-related cancer (National Fallen Firefighters Foundation, 2020). Although the NFPA and USFA recognize the important research that must be done in the realm of occupationally related illnesses, such deaths fall outside of their current criteria. Also, if the Department of Justice (DOJ), Public Safety Officers Benefit (PSOB) program categorizes a firefighter death as *in the line of duty*, the NFFF also recognizes the death as an LODD. This recognition is unique to the Foundation.

Figure 1 provides data on firefighter fatalities in the United States from all three agencies from 2008 to 2018 along with a trend line indicating how the data has changed statistically over that 11-year period. Figure 1 also shows the number of firefighters who succumb to cardiac events each year based on data from the three different agencies.

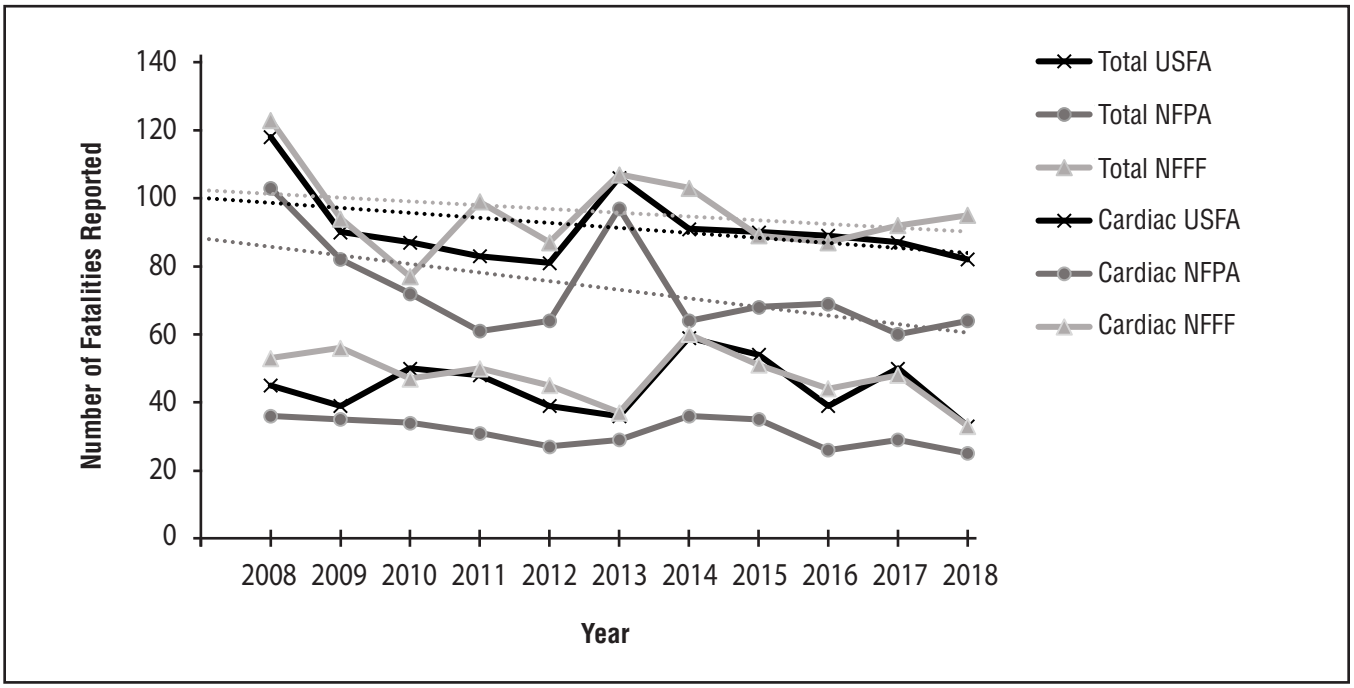
A review of the data presented in Figure 1 indicates that approximately 100 firefighters die in the line of duty each year based on USFA and NFFF criteria. While the trend line for all three reporting agencies for the period points downward, the decreases in fatalities are not as great as many would like. This is especially the case given the numerous major initiatives, including the 16 Life Safety Initiatives promulgated in 2004, with a focus on reducing preventable firefighter fatalities (Everyone Goes Home, 2019). Other initiatives that address firefighter health and seek to address preventable line of duty death include the Wellness Fitness Initiative, sponsored jointly by the International Association of Fire Chiefs (IAFC) and the International Association of Firefighters (IAFF), and the National Volunteer Fire Council's (NVFC) Heart Healthy Firefighter Program, launched in 2003 (National Volunteer Firefighter Council, 2020).

Also apparent from the data, cardiac deaths account for approximately 50% of all firefighter fatalities. In this data, the average percentage of sudden cardiac death across all three agencies for the 11-year period is 49%. While firefighter fatality statistics are important to track and provide useful information, they fail to provide insights about how to change the status quo.

The National Institute of Occupational Safety and Health (NIOSH) Fire Fighter Fatality Investigation and Prevention program investigates line of duty deaths (National Institute of Occupational Safety and Health, 2020). The program publishes online reports to summarize lessons learned from these tragedies. A review of the cardiac-related reports reveals four primary concerns related to medical evaluations:

1. The firefighter had not received a medical evaluation for firefighting.
2. The firefighter was inappropriately cleared by a health care provider who did not understand the strenuous nature of the job or the environment in which it is performed.
3. The medical evaluation identified medical conditions that did not prevent the firefighter from being cleared for duty but required follow-up (and usually the firefighter was told to follow-up with his or her primary care physician), but the firefighter did not seek follow-up care.
4. The medical evaluation did not identify evidence of cardiovascular disease.

Figure 1. Number of Total Fatalities and Cardiac Fatalities Reported by USFA, NFPA, and NFFF from 2008-2018.



Medical Evaluations for Firefighters

Major fire service organizations and researchers routinely call for medical evaluations as an important part of the strategy to reduce preventable line of duty deaths in the fire service. In 1974, the technical committee responsible for the professional qualification standards for firefighters (NFPA 1001: *Standard on Fire Fighter Professional Qualifications*) called for candidates to be examined by a physician prior to engaging in firefighter training. Beginning in 1987 with the initial publication of *NFPA 1500: Standard on Fire Department Occupational Safety and Health Program*, annual medical evaluations became a component of formal safety and health surveillance systems for firefighters. In 1992, *NFPA 1582, Standard on Medical Requirements for Firefighters* was published. In 2007, NFPA 1582 was renamed and is now known as the *Standard on Comprehensive Occupational Medical Program for Fire Departments*. The NFPA 1582 Standard is a consensus-driven industry standard on occupational medical programs.

The stated purpose of the 1582 Standard is to "outline an occupational medical program that, when implemented in a fire department, will reduce the risk and burden of fire service occupational morbidity and mortality while improving the health, and thus the safety and effectiveness, of firefighters operating to protect civilian life and property" (NFPA 1582, p. 6). In order to achieve that purpose, the standard specifies the 1) minimal medical requirements for candidates, 2) occupational medical and fitness evaluations for members, 3) essential job tasks, and 4) the methods and types of data that must be collected.

Many fire departments and firefighters advocate for and maintain that medical evaluations serve a wider purpose than just providing clearance. The medical evaluation is also an opportunity for early detection of disease and provides a powerful opportunity to motivate change in lifestyle choices that are related to decreasing the risk of disease and sudden incapacitation. Such an interpretation is consistent with the goals of an occupational medical program and reinforce the notion that medical evaluations are most powerful when they are delivered as part of a comprehensive occupational medical program that provides support for firefighters' health beyond simply clearing them for duty.

The IAFF, IAFC, NVFC, and the NFFF have been stalwart advocates for medical evaluations for firefighters through demonstrated action, publications, and implemented programs. Since 1997, the *Fire Service Joint Labor Management Wellness-Fitness Initiative* has been a guiding document for departments seeking to implement a comprehensive program focused on firefighter wellness and fitness. In 2013, the IAFC published *A Fire Department's Guide to Implementing NFPA 1582*. In 2016, the IAFC published *A Healthcare Provider's Guide to Firefighter Physicals* written for healthcare practitioners delivering NFPA 1582 medical evaluations to firefighters. This document is an easy-to-reference guide that can be handed to practitioners who may not be familiar with the specific requirements associated with the standard. In 2017, the IAFC Safety, Health and Survival Section published *The Emergency Services Road Map to Health and Wellness.* The NVFC has issued a position statement supporting annual medical evaluations for all firefighters and has developed a website dedicated to the resources associated with implementing medical evaluations. The First Responder Center for Excellence (FRCE) has taken a role advocating for annual medical evaluations and distribution of the *Healthcare Providers Guide for Firefighters Physicals*, which is focused on providing a brief summary of the exposures firefighters face and recommended screenings.

Not only has the national fire service promoted the adoption of medical evaluations, fire service researchers have also advocated for medical evaluations as an important strategy to reduce preventable line of duty deaths. For example, in a 2016 invited editorial in *Circulation*, Kales and Smith (2017) outlined the cardiovascular strain of firefighting; detailed research findings from clinical and autopsy studies; and opined that an important step in reducing duty-related deaths was having all firefighters medically evaluated annually.

Despite the nearly universal agreement that medical evaluations are necessary for firefighters, including the recommendations in NFPA 1582 that firefighters receive an annual medical evaluation, there is a startling lack of information available about how many firefighters are receiving medical evaluations and what components are included in the medical evaluations. **Table 1** provides a summary of the limited data that is available from several sources addressing the adoption of medical evaluations in the fire service.

In a NIOSH ALERT addressing cardiovascular disease published in 2007, the authors reviewed the NIOSH firefighter fatality investigation reports completed after line of duty cardiovascular deaths (National Institute of Occupational Health and Safety, 2007). A sample of 131 fire departments (including career, volunteer, and combination departments) had experienced a cardiovascular-related death. As reported in Table 1, of these departments, 71% reported they performed medical evaluations on candidates, but only 31% of the departments reported regular medical evaluations for incumbent firefighters (National Institute of Occupational Health and Safety, 2007). Caution is warranted in generalizing to the entire fire service from such a small sample and the data is based on fatalities that occurred prior to 2007. Further, it is possible that this sample is biased in that departments without medical evaluations may be more likely to experience a cardiac death. Regardless of these limitations, the low rate of medical evaluations is concerning.

Table 1. Data Available on the Adoption of Medical Evaluations in the Fire Service

Sample/Survey	Date	Sample Size Career & Volunteer	Requiring Exams (%)	Sample Size Career	Requiring Exams (%)	Sample Size Volunteer	Requiring Exams (%)
NIOSH Alert	2007	131 departments	31%				
NFPA	2015	5,106 departments	21%				
IAFC Membership Survey v1	2006			805 people	69%	251 people	47%
IAFC Membership Survey v2	2017			5,607 people	79%*	2,157 people	46%*
Women's Survey	2018			2,389 people	64%	775 people	41%

*Question asked if departments recommend, require, or provide evaluations. It cannot be discerned what percentage of departments both required and provided evaluations for their personnel.

The IAFC has conducted two surveys of their membership to gauge the practices around department medical evaluations. In 2006, 46.6% of respondents from volunteer departments and 69.2% of respondents from career departments reported requiring annual medical evaluations for all firefighters (Fischler, 2016). In a more recent survey, 79% of career respondents and 46% of volunteer respondents indicated their departments require, recommend, or provide annual physicals (Haddock, Jahnke, & Poston, 2017). It should be noted that the question about annual medical evaluations in this survey included "requiring, recommending and providing physicals" (Haddock et al., 2017, p. 2). Thus, it is unclear if the medical evaluations in these survey results were required to stay on the job. A noted limitation of both surveys is that they surveyed the full membership of the organization and it is possible some departments are represented more than once. It is also possible that there was a selection bias in that only people interested in annual evaluations chose to take the survey.

According to the *Fourth Needs Assessment of the U.S. Fire Service* (National Fire Protection Association, 2016), only 27% of departments reported having a program to maintain basic firefighter fitness and health. Of those that indicated they had a program, 79% reported that the program included a firefighter medical evaluation (National Fire Protection Association, 2016). Given the low rate of departments that reported having a health and fitness program, only 21% of the total departments surveyed indicated they provide medical evaluations. It is possible that there were departments that do provide medical evaluations but do not consider them to be falling within a *fitness and health* program. The overall response rate for departments was 19%. As is typically the case, generalizability of findings to departments that did not respond to the survey is questionable.

In 2018, a survey of health and wellness for women in the fire service was conducted using snowball sampling techniques (Jahnke, unpublished data). One of the domains assessed included department medical evaluations. Of career firefighters surveyed, 64% indicated their department required medical evaluations. Only 41% of volunteer firefighters indicated their department required medical evaluations. Similar to the limitation of the IAFC surveys, the sample was firefighters and not departments so it is unclear how many women from the same department completed the survey. Given the snowball sampling, it is likely that women from the same department completed the survey. However, the broad scope of the survey suggests that there was likely not a response bias specific to medical evaluations.

While data sources varied and each survey has its limitations, rates across the board present a disturbing picture of the current state of medical evaluations for firefighters. Rates do vary significantly whether individuals or departments are asked the questions. It is most likely that asking individuals inflates the numbers. Asking multiple individuals from the same organization can lead to repeat counts of departments providing or requiring medical evaluations. Clearly, volunteer firefighters receive medical evaluations at a rate much lower than career firefighters. However, even evaluation rates of career firefighters are disappointing given the risks of the job and the effort that national organizations have devoted to ensuring that firefighters receive proper medical evaluations. Plainly, there is a need for fire service leaders to act locally to ensure that firefighters are receiving the most appropriate medical evaluations.

Additional limitations to the available data also exist. For instance, reports published to date and NFPA 1582 recommendations are focused on structural firefighters. Little is known about what is provided to or should be required of firefighters in other roles such as wildland

firefighting. There is also a lack of research data on what components of a medical evaluation are included or standards (OSHA, DOT, NFPA, other) are used for those evaluations and the extent to which those evaluations vary by departments. It would also be useful to know what types of providers (e.g. occupational medicine specialists, primary practice, mid-level providers) are performing the evaluations and what program components from NFPA are being implemented.

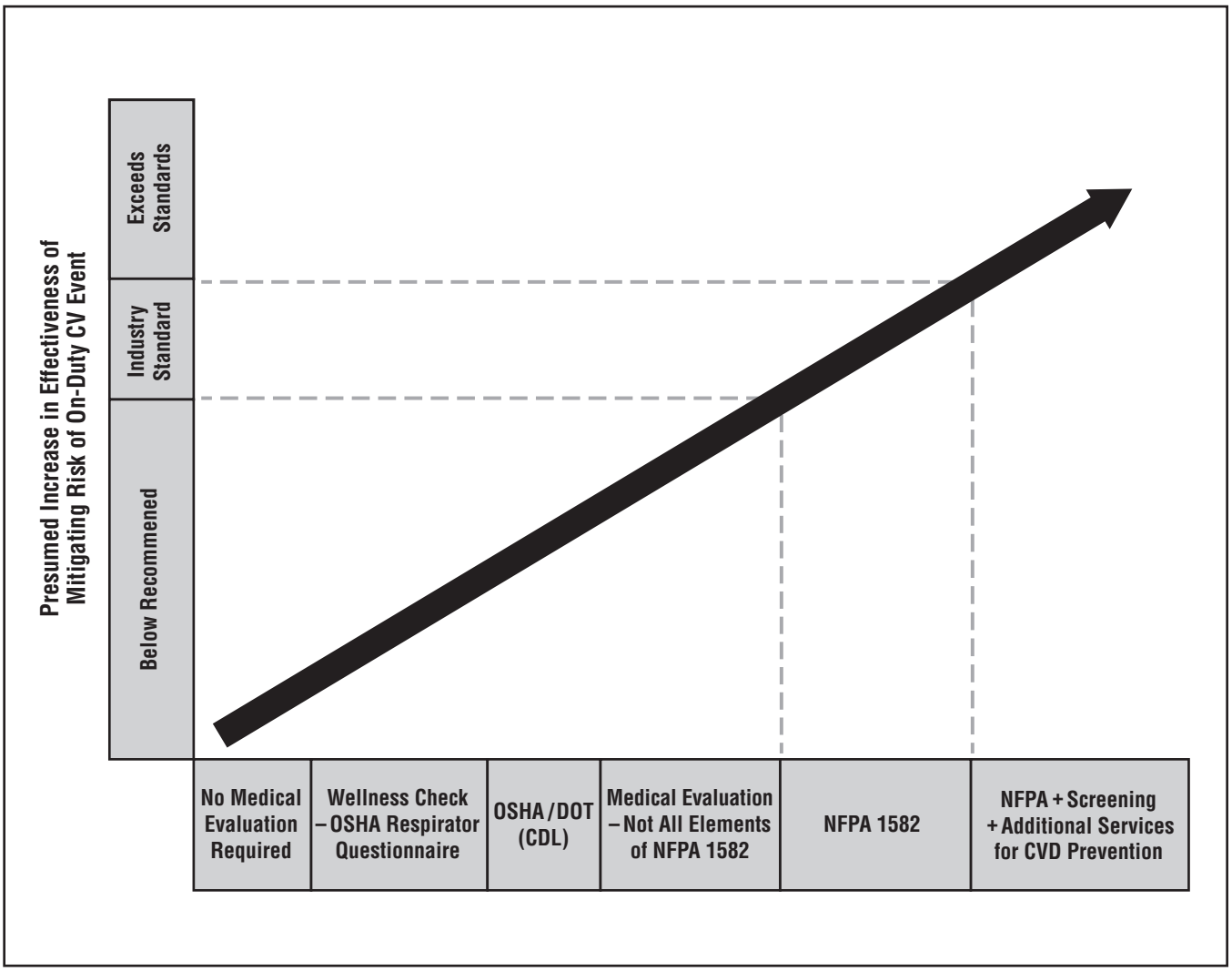
In summary, there is surprisingly little data available on the extent to which firefighters receive medical evaluations. The data that is available varies greatly in the estimate of firefighters receiving medical evaluations and suggests that there are differences between paid and volunteer departments. One thing that is clear from the available data is that more research is necessary to elucidate how many firefighters are receiving medical evaluations. Additionally, the available research provides almost no insights into how the medical evaluations are being delivered, the quality of the medical evaluations that are being performed, or how the evaluations are paid for.

Approaches to Providing Medical Evaluations for the Fire Service

Despite widespread agreement that firefighters should be medically cleared before engaging in firefighting activities, not every firefighter is receiving a medical evaluation. How medical evaluations are delivered across the United States and the quality of the medical evaluations may be just as important as knowing how many fire departments require some sort of medical evaluation. In reality, there are many different models of how medical evaluations for firefighters are being accomplished. As seen in **Figure 2**, approaches to providing evaluations vary considerably ranging from no medical evaluation to exceeding NFPA 1582 requirements. Evaluations that are considered below the standard for medical evaluations include the OSHA Respirator Questionnaire (or other "wellness check"), OSHA/DOT's occupational medical exam to permit driving, and medical evaluations that do not adhere to NFPA standards.

NFPA 1582 should be considered the baseline of a comprehensive medical exam rather than a "gold

Figure 2. Provision of Medical Evaluations for Firefighters (Candidates and Incumbents)



standard" exam. While there is no available research to date documenting better health outcomes (or lower line of duty deaths) among fire departments that use the more comprehensive medical evaluations, most experts and fire service organizations urge that firefighters receive a 1582-compliant medical evaluation by a health care professional who understands the physiological stress of firefighting and the environment in which it is performed (National Fire Protection Association, 2016; National Volunteer Firefighter Council, 2020; International Association of Fire Fighters, n.d). In fact, the NFPA 1582 medical evaluation is considered by most to be the industry standard as a baseline examination for ensuring that firefighters are adequately tested.

As seen in **Table 2**, a comprehensive occupational medical program includes many components beyond the medical evaluation of candidates and incumbents. These components complement medical evaluations by providing other medical services that are needed by firefighters and by assisting the fire department with surveillance and research. While many fire departments do not meet the NFPA 1582 Standard in terms of medical evaluations, some more progressive departments are providing testing beyond the minimum recommendations provided in NFPA 1582. These departments are often aware of the limitations of conventional risk factors, or even exercise stress tests, to uncover occult (undetected) coronary artery disease and are seeking more definitive screening tools. A team of researchers has recently received an Assistance to Firefighter Grants (AFG) award, titled *BETTER HEART: Building Evaluations That Translate Evidence and Research for Health Evaluations And Related Training* (EMW-2017-FP-00445), to work with fire departments and health care providers to review current medical literature and fire service research to develop enhanced cardiac screening recommendations for the fire service.

Table 2. Comparison of Delivery Models of Medical Evaluations in the United States Fire Service

Medical Evaluations and Clearance
• For candidates
• For incumbents
***Comprehensive Services**
• Candidate Assessments
• Annual Incumbent Assessments
• Worker's Compensation Injuries
• Infectious Disease Exposure
• Return to Work Assessments
****Surveillance**
• Full range of health screenings (prevention, treatment, behavioral health)
• Long term surveillance of occupational exposures
• Research

Models for Delivering NFPA 1582-Compliant Medical Evaluations

While there is consensus that every firefighter should receive a medical evaluation consistent with the 1582 Standard, there is a great deal of variation in how NFPA-compliant medical evaluations are provided depending upon resources and local conditions. **Table 3** identifies different models for the delivery of a 1582 medical evaluation. For cost and other reasons, many departments offer or require a medical evaluation that is not NFPA-compliant or that is not performed by an occupational health care provider who understands the work of firefighting. In these cases, there is danger in a firefighter being inappropriately cleared for duty. There is very real concern that these medical evaluations provide a false sense of security.

In the largest and most well-resourced departments, an occupational health medical surveillance program is a division within the department wherein the staff are employees of the jurisdiction. In this model, incumbents and candidates are evaluated by an occupational health team focused exclusively on firefighters.

Another model for the delivery of a comprehensive occupational health program for firefighters transfers the personnel responsibilities for staffing an occupational health program from the jurisdiction to a contractor, often a medical group that bids for the provision of services. This contract-based delivery of medical evaluations may rely on locating the medical surveillance facility within a fire department or at a location provided by the contractor. The most comprehensive programs are designed to not only address candidate and incumbent annual medical evaluations, but also return-to-duty medical evaluations. These programs may also provide extensive health and wellness services beyond the medical evaluation, including but not limited to nutrition counseling, medical evaluation, occupational therapy, work hardening, rehabilitation from injury or illness, behavioral health counseling, and other services.

In many communities, private occupational health providers provide annual medical evaluations in accordance with NFPA 1582 and limit their scope of practice to the delivery of such services. Contracts are typically awarded based on a bid process to an individual within the community or to a company/clinic that travels and provides exams on site within the fire departments.

Outside of the occupational medicine world, fire departments may contract with a family practice/internal medicine group to administer their medical surveil-

Table 3. Ways to Implement NFPA 1582 Standards

Provider Type	How Provided	Payment Covered By	Location	Comprehensive Medical Surveillance Services
Occupational Medicine Professional	Division of the fire department	AHJ	Within fire department	Includes comprehensive services* and surveillance**
Occupational Medicine Professional	Contracted service	AHJ	Fixed or mobile clinic	Typically includes comprehensive services* and surveillance**
Family practice/Internal medicine provider	Contracted service	AHJ	Health care provider's office	May include comprehensive services* or be limited to medical clearance evaluations
Hospital based/Private practitioner	Community service	Hospital or individual provider	Hospital or health care provider's office	Usually limited to medical clearance
Private practitioner/ Urgent care		FF out of pocket or insurance	Provider's office or clinic	Usually limited to medical clearance

Note: For a list of comprehensive services and surveillance activities, see Table 2.

lance program. In this model, the health care providers performing the medical evaluations sometimes provide a primary care physician for the firefighters. The focus of the practice may be on the general population and it is critically important to ensure that the physicians understand "healthy worker effect" in the context of their general practice. Family practitioners may rely on the recommendations found in the United States Preventative Health Task Force for their primary patient population but fail to set them aside when assessing firefighters. Inappropriately applying such recommendations to firefighters has the potential to create a false sense of security without considering the unique working conditions that impact firefighter health.

In some jurisdictions, fire departments may partner with a local hospital (staffed by hospital-based physicians) or even a sole practitioner in the community to administer medical evaluations and, potentially, a surveillance program. Meeting the requirements for NFPA 1582 including spirometry, audiology, and exercise stress testing may be challenging if the infrastructure does not exist locally to complete such testing. In very rural areas, candidates and incumbent firefighters may be faced with long travel distances to complete the testing required for the physician to determine suitability for safely performing work in accordance with NFPA 1582.

Some fire departments place the burden of obtaining medical clearance on the firefighter. Candidates may be required to obtain a medical clearance from their own physician or, absent a family doctor, seek clearance from a physician at an urgent care center. In this model, fire departments may provide candidates with the essential functions of a firefighter as outlined in NFPA 1582 and direct the candidate to obtain a medical clearance from a healthcare provider. The determination of successfully obtaining a clearance is left to the discretion of the healthcare provider. Given demand on physician time and resources, the ability to conduct a comprehensive exam that meets the standard can be of concern. Equally concerning is the ability or willingness of the health care provider to review results with the firefighter and provide meaningful feedback and guidance on maintaining or improving health, or the need to address health concerns that may worsen over time placing the firefighter at greater risk in the future.

Understanding the costs and benefits associated with different models of delivery is important. First, not all medical professionals are equally versed in the unique health issues that firefighters encounter. Second, the process for being cleared to function as a firefighter may differ from provider to provider based on interpretation of NFPA 1582 and medical judgement. Third, a medical provider who does not know the demands of firefighting may rely on false assurances from the firefighter such as—*"All I do is drive the apparatus*."

Challenges to Implementing Medical Evaluations

In a qualitative study of perceptions, experiences, and opinions related to firefighter medical evaluations, Jahnke, LeDuc, Poston, Haddock, and Jitnarin (2015) found a number of barriers to program implementation including cost, buy-in from personnel and agency/ membership relationship implications, time constraints, and effectiveness of exams.

The cost of an annual NFPA 1582 medical evaluation can range from $250 to over $1,000 depending on the diagnostic testing performed. Although the costs may be defrayed by grants or charitable donations, the expense of delivering the medical evaluations remains. Departments that simply cannot afford to pay for the physicals for either candidates or incumbent firefighters may still seek to ensure that their personnel are safe to perform the essential functions of the job. For

incumbent firefighters, the authority having jurisdiction (AHJ) may provide health insurance and similarly require them to obtain an annual medical evaluation with a similar clearance process based on the essential functions outlined in NFPA 1582. Incumbent firefighters may be required to pay for co-pays and deductibles associated with the use of their employer-provided insurance plan. While not considered ideal in its cost-sharing requirement, this model may be viewed as a viable alternative to no surveillance program of any kind.

Smaller fire departments have also found alternatives to providing annual medical evaluations through a variety of other mechanisms. First, departments have applied for and been awarded Assistance to Firefighter Grants through the Department of Homeland Security. Funding for medical evaluations can be requested under Wellness/Fitness in the regular AFG criteria. Funding can also be requested under the Staffing for Adequate Fire & Emergency Response (SAFER) grants recruitment/retention program. Local grants administered through state and private entities have also been awarded to defray the costs associated with providing medical evaluations to firefighters.

Second, even smaller departments have partnered with their local hospitals and private practitioners to provide free medical evaluations for their firefighters. This model typically involves agencies with 20 or fewer firefighters and charitable write-offs by the healthcare system providing the examinations. Unfortunately, according to personnel within the AFG program, only 2% of requests are for funding physicals each application round (Patterson, personal communication, 2020).

There are also challenges with overcoming perceptions that the medical evaluation is intended to exclude firefighters from providing service within their communities. No firefighter ever wants to be told that they must leave the fire service under any circumstances. Such self-determination represents a profound willingness to sacrifice their own lives in the name of being able to serve their community and maintain their title, or self-worth, as a firefighter. Fire Chiefs are reluctant to tell someone they cannot perform the essential functions of a firefighter, in part because of the implications on staffing.

One of the biggest fears associated with participating in a medical evaluation program is the fear that a failure to obtain a clearance translates into immediately having to leave the service. Evaluating a similar department's experience with annual medical evaluations can allay this fear. Experience of the authors suggests that these fears are exaggerated. In departments that we have consulted, very few firefighters are permanently removed from duty. As an illustration, of 100 firefighters who may participate in an NFPA 1582 compliant medical evaluation, approximately 85-90 will immediately pass without issue. An additional 10-14 may require some form of follow-up or intervention (additional testing, medication, procedure, change in lifestyle), but they will not be removed from duty. Only one person may be found to have a serious and potentially uncorrectable medical (cardiovascular, orthopedic, metabolic) condition and may choose to leave the fire service rather than engage in the process of having the identified condition corrected (e.g., choose not to have invasive surgery) or may not receive medical clearance.

The risk of losing line firefighters is also concerning for volunteer departments that may be struggling with recruitment and retention. The concern is that if medical conditions that limit job duties are found and take the volunteer firefighters out of service, there will not be enough personnel to respond to calls. Such risks must always be balanced against the risk of a firefighter suffering a sudden cardiac event during firefighting operations, potentially impacting the ability of other firefighters to survive the event attempting to rescue a fellow responder.

Fire service personnel also cited time constraints as a barrier to medical evaluations. This challenge is particularly taxing for volunteer firefighters who often perform their duties as a second or third job. Particularly in more rural areas where the closest exams are at a great travel distance, firefighters report finding it difficult to get tested. For career fire departments, taking firefighters out of service to have examinations can be a problem for staffing. Some departments have sought on-site exams where clinicians come to the stations to conduct the testing saving the time in travel and limiting time out of service.

Finally, questions concerning the effectiveness of medical evaluations were cited as limiting enthusiasm for exams among some personnel. There are instances where firefighters receive information about whether they passed or failed the examination with little or no feedback or follow-up on health parameters. While providers view themselves as only serving the role of providing clearance to be on the job, firefighters often report that their work-related medical exams are their only annual medical visit and view their provider as their primary care physician. A lack of details and recommendations based on the results of the exam were reported to raise concern for firefighters about the exam effectiveness and can result in limited buy-in from personnel. If medical evaluations are used to foster more communication between medical providers and the fire department and the individual firefighter, some concerns about the evaluations can be transformed into strengths. Individual firefighters should receive useful feedback about individual health metrics and educational material about improving health and decreasing risk.

Additional Research

Available data, and more importantly, the data that was not available highlight the need for additional research

on the provision of medical evaluations to firefighters. Even basic quantification of the scope of fire service medical evaluations is needed given the disparate rates available in the literature. The cost benefit of evaluations and preventive programs, as well as the impact on cardiovascular health also needs to be further examined. Additional research is also needed to understand how many firefighters are getting medical evaluations; how many firefighters require medical follow-up for various conditions; and how many firefighters are required to change employment status because of a medical evaluation.

More research with occupational health care providers is necessary to understand what type of testing is most effective for identifying early heart disease (and cancer) and what are the most effective strategies to educate firefighters about specific conditions and to motivate healthy lifestyle changes. Ideally, medical evaluations should only be one part of a comprehensive wellness program and more research is needed to understand how to most effectively educate firefighters with information from their medical evaluations to improve their own health. As more efforts are focused on these important research questions, additional work must also be done to develop more sensitive mechanisms focused on identifying occult cardiovascular pathologies in otherwise healthy-appearing firefighters. The NFPA 1582 Standard is not the "gold standard" in ensuring that firefighters are NFPA-compliant to perform the arduous tasks of firefighting—it is the minimum standard. Research should continue to explore leading-edge strategies to reduce preventable line of duty deaths as a result of sudden cardiac events.

The BETTER HEART program has brought together a group of researchers, health care providers, and fire service leaders to provide evidence-based recommendations for enhanced cardiovascular screenings for firefighters and to explore strategies for implementing these recommendations in departments. This project may inform both the NFPA 1582 Standard and individual fire departments that wish to exceed minimum standards to better ensure the health and safety of their members.

Conclusion

Firefighters perform strenuous physical work in extreme environments under significant psychological stress (Kales & Smith, 2017). Virtually every nationally-recognized fire service organization (IAFF, IAFC, NVFC, USFA, NFPA, NFFF) recommends that firefighters receive an occupational medical evaluation to ensure that they can safely perform the essential job tasks without undue risk. The NFPA 1582 Standard provides a consensus recommendation on the medical evaluations for candidates and members. Despite this Standard, sudden cardiac events remain a leading cause of duty-related death. Notwithstanding the importance of medical evaluations in the fire service, there is still very little systematic, science-based research documenting key features of medical evaluations or their applicability in assessing cardiovascular health.

NFPA 1582 is the minimum industry standard for medical evaluations and every firefighter should receive a medical evaluation annually. However, sudden cardiac deaths have occurred in firefighters who have been cleared for duty. Additional work should be done within the scientific community, occupational health community, and the fire service to identify meaningful ways to go beyond the minimum standard in protecting firefighters. Such research should be based on empirical science so that new testing can more effectively reveal occult coronary vessel disease not found during an NFPA 1582 physical.

A final consideration for fire service leaders is that the medical evaluation, while critical, is not sufficient. Pro-actively implementing programs to control modifiable risk factors including weight, blood pressure, cholesterol, tobacco and alcohol use, sleep deprivation, and behavioral health form the basis of a comprehensive medical surveillance program necessary to minimize the likelihood of suffering a line of duty death due to a sudden cardiac event.

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About the Authors

Matthew Tobia is Chief with the Harrisonburg (VA) Fire Department and is a 30-year student of emergency services. He holds a Bachelor of Science degree from the University of Maryland, Baltimore County and is a graduate of the Executive Fire Officer program. Matt has served as a member of the Editorial Board for *Fire-Rescue Magazine* and has authored over 120 articles. He is also the former chair of the IAFC's Safety, Health and Survival Section, holds the Chief Fire Officer credential, and is a member of the Institute of Fire Engineers. Chief Tobia is active with the National Fallen Firefighters Foundation (NFFF) and the Mid-Atlantic Burn Camp for Children.

Sara A. Jahnke, Ph.D. is the Director and Senior Scientist with the Center for Fire, Rescue & EMS Health Research at the National Development & Research Institutes - USA. She has served as the principal investigator on several large-scale studies with the fire service focused on health and wellness. She is an active member of the Safety, Health and Survival Section of the International Association of Fire Chiefs and serves as scientific consultant to several fire service organizations such as the National Fallen Firefighters Foundation, the National Volunteer Fire Council, and The First Twenty.

Chief Todd J. LeDuc, (Ret.), MS, CFO, FIFirE recently retired as Executive Assistant Fire Chief of Broward County (FL) after 30 years of service. He serves as Chief Strategy Officer for Life Scan Wellness Centers, a national provider of comprehensive physicals and early detection exams. He has served as a member of the International Association of Fire Chiefs' Safety, Health & Survival Section for well over a decade and is currently Secretary of the Section. He is a peer reviewer for both professional credentialing and agency accreditation. He is editor of *Surviving the Fire Service* (2020), published by Fire Engineering Books and Videos. Chief LeDuc serves on numerous advisory boards and publications.

Denise L. Smith, Ph.D. is a Professor of Health and Human Physiological Sciences at Skidmore College (NY) where she directs the First Responder Health and Safety Laboratory. She is also a Research Scientist at the University of Illinois Fire Service Institute. She completed her doctorate in Exercise Physiology at the University of Illinois. Dr. Smith has coauthored an Exercise Physiology textbook, an Advanced Cardiovascular Exercise Physiology textbook, seven book chapters, and over 80 scientific papers. She has received over $12 million in federal funding from FEMA-AFG, DHS S&T, NIOSH, and DOD to pursue her research agenda aimed at understanding the physiological strain of firefighting and the health risks it imposes on firefighters. Specifically, her research is focused on the cardiac, vascular, and coagulatory changes that occur during emergency operations and how these changes increase the risk of sudden cardiac events. She is a fellow of the American College of Sports Medicine (ACSM), a member of the National Fire Protection Association (NFPA) Fire Service Occupational Safety and Health committee, an investigator for the National Institute of Occupational Safety and Health (NIOSH) firefighter fatality investigation and prevention program, and an Honorary Battalion Chief at Hanover Park FD (IL). Dr. Smith is a passionate advocate for firefighter health and safety and routinely lectures at national and international conferences.

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