

Fitness-for-Duty Assessments of Industrial Firefighters: Guidance for Occupational Medicine Physicians

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Industrial firefighters share many characteristics with municipal firefighters; however, employers frequently have not addressed or characterized the unique job duties, hazards, and specific physical/mental demands associated with industrial firefighting. In addition, gaps exist in the medical literature with regard to industrial firefighter demographics, behavioral risk factors, and chronic diseases. Finally, the proper methodologies for fitness-for-duty assessment of employees acting in this capacity are lacking. To address these gaps, the American College of Occupational and Environmental Medicine (ACOEM) convened a Task Force in 2014, to develop fitness-for-duty guidance for industrial firefighters. This document highlights these gaps and suggests research opportunities to enhance the health and safety of this population. While an extensive literature review found a lack of studies for this population—thus excluding the development of an evidence-based document—sufficient materials were available from which to draw preliminary conclusions, considerations for best practices, and recommendations for future studies.

In October 2014, the American College of Occupational and Environmental Medicine (ACOEM) convened a Task Force of medical practitioners, corporate medical directors, university professors, and fire chiefs having a working knowledge of US oil and gas and petrochemical

industries to develop fitness-for-duty guidance for industrial firefighters and address the lack of standards and guidance specific to this population. This lack of a standardized approach could result in firefighters being improperly assessed for their capability to safely perform industrial firefighting duties and puts the firefighter, his/her coworkers, the workplace, and the community at risk. This increased risk has the potential for increased liability to business entities employing industrial firefighters.

In addition to recommending best practices for the determination of an industrial firefighter's fitness-for-duty, an important part of the Task Force's charge was to characterize where possible, the demographic make-up of the industrial firefighter. Such knowledge is essential to differentiate industrial from municipal firefighters particularly as it may relate to cardiovascular disease, the most common cause of work-related mortality among municipal firefighters. As an additional benefit, this information has the potential for conducting directed studies that will advance the health and safety of the industrial firefighter population.

METHODOLOGY

Task Force members identified a list of questions (identified under the section on Topics Reviewed) for which the systematic literature review would seek to document the current state of affairs. Literature searches utilized Medline, PubMed and PubMed Central, and National Library of Medicine databases to identify and characterize the relevant literature for industrial and municipal firefighters, identify gaps that exist for the industrial firefighters, and advance recommendations to address literature gaps.

The Task Force then designed a questionnaire (Appendix 1) for industrial firefighters to identify the following information:

- demographics
- level and frequency of firefighting duties
- patterns and frequency of training
- variations in the medical clearance process
- access to and involvement in employer-directed regular fitness activities
- risk factors for cardiovascular disease

The questionnaire was reviewed by the University of Pennsylvania Institutional Review Board (IRB), which concluded the project did not meet the criteria to be considered human research and was thus exempt from further IRB oversight. The Task Force engaged ORCHSE Strategies, LLC, a health, safety, and environmental control network that sponsors a cross-industry forum for purposes of benchmarking and sharing best practices, to host the online questionnaire. ORCHSE member companies reached out to their firefighters to complete the questionnaire. No identifiers were included in the questionnaire and data collected were anonymous and confidential. The Task Force members received only aggregate responses to the questionnaire for analysis.

The Task Force identified five questions for systematic literature review to document the current state of affairs in each area:

1. What are the differences in job duties for municipal versus industrial firefighters?
2. How can cardiovascular fitness for duty be best determined for industrial firefighters?
3. Are tools currently used to determine fitness for duty useful?
4. What preventive interventions are available and how effective are they?
5. How do US laws impact fitness-for-work decisions?

DIFFERENCES IN JOB DUTIES—MUNICIPAL VERSUS INDUSTRIAL FIREFIGHTERS

As previously noted, fitness-for-duty standards and guidance specific to the industrial firefighter population is lacking. The National Fire Protection Association Standard on Comprehensive Occupational Medical Program for Fire Departments (NFPA 1582), does not include industrial fire brigades in its medical assessment standard.¹ The NFPA 600 Standard on Facility Fire Brigades contains only minimal reference to the medical clearance process.² This lack of guidance has contributed to the presence of multiple, differing firefighter assessment methodologies across various industries.

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NFPA 600 classifies facility fire brigades as either incipient stage firefighting, advanced exterior firefighting, or interior structural firefighting.² The incipient stage involves fighting a fire in normal clothing using extinguishers or smaller hand lines (125 gpm). It also requires no evasive actions (eg, crawling to escape heat or smoke), and does not necessitate the use of bunker gear or self-contained breathing apparatus (SCBA).² Advanced exterior or interior firefighting involves full gear, teams in warm and hot zones utilizing SCBA, attack teams of two or more, established communication systems, experienced members overseeing those less experienced, and the requirement of annual live fire drills. NFPA 600 states that facility fire brigades are exposed to the same degree of hazard as community firefighters, but these hazards do not extend beyond the private facility where they work.²

NFPA statistics from 1996 to 2000 have found that the risk of death in commercial fires exceeds residential fires by more than 60%.³ Calls to industrial fire departments number less than 100 annually compared with several thousand calls for community fire fighters.⁴ For both groups, the vast majority of the calls are not for fires, but rather for emergency medical services.

To understand industrial firefighter job duties, the Task Force interviewed industrial fire chiefs, fire school faculty, fire team medical directors, and industrial firefighters. In general, there are many similarities between industrial and community (volunteer, municipal, woodland) firefighters. Industrial firefighters are exposed to many of the same physical hazards—including impaired heat exchange from gear, sun, wind, rain, snow, extreme temperature fluctuations, humidity, wetness, mud, skin contact with oil and grease, bloodborne pathogens, noxious odors, and respiratory irritants. Mental health stressors include crucial decision-making, aspects of sustained work, unpleasant situations, and shiftwork and related fatigue.

Many physical demands are also similar including the need for explosive strength (running, jumping, rapid pulling, advance hose line), manual dexterity (assemble machinery, operate hand tools, tie knots on hose, use a wrench), climbing, vision (acuity, depth perception, night vision, color-coding), smell (leaking and burning), and speech and hearing. Municipal firefighting equipment and hoses tends to be smaller, whereas industrial fire equipment and hoses tends to be more heavy duty. This means the industrial firefighter is often handling heavier loads. The physical demands on municipal firefighters emphasize upper body and overhead work (“overhaul”). Industrial fire brigades tend to require less upper body

strength but the heavier nature of the equipment may put industrial firefighters at increased risk for back injuries.

Industrial firefighting is also significantly different from community firefighting in that the knowledge required is more specific for the local setting (eg, explosive, chemical, or marine situations). Municipal and industrial firefighters wear standard structural firefighting clothing whereas industrial firefighters’ clothing may include high temperature protective and chemical protective clothing.⁵ Resulting dehydration and hyperthermia are often a greater issue for industrial firefighters particularly in those with poor cardiovascular conditioning and chronic disease. In the survey developed by this Task Force, the majority of industrial firefighters who have been community firefighters feel the physical work is similar, but the mental demands and danger are greater per episode of industrial firefighting.

In larger cities, municipal/structural firefighters are generally full-time paid positions, whereas industrial fire brigades and smaller city municipal fire departments are part-time, volunteers called to duty only when needed. Most industrial fire brigade members are plant operators or have some other full time job in the facility where they work. Often, full-time paid municipal firefighters engage in an exercise regimen as part of their regular work duties. Municipal firefighters may also plan and prepare food at fire stations. Occasionally, there are also firefighter wellness and health offerings. Industrial firefighters rarely have dedicated work time for exercise, meals, or wellness activities specifically related to the fire team. Consequently, while strength and health maintenance activities may be encouraged for industrial fire teams, these activities may need to be performed outside of work hours.

Typically, municipal firefighters work 24 hours on and 48 hours off (24/48) shifts or 48/96 shifts.^{6,7} Industrial fire brigades on the other hand usually work 8 to 12 hours, often with rotating shiftwork for 24-hour plant operations. As shiftworkers have increased health risks for obesity, diabetes mellitus, and hypertension, firefighters of all types may also have shift-work-related health risks.

There are also tactical differences in the way fires are approached.⁸ Industrial fires tend to be larger petroleum-based or pressurized gas fires where the emphasis is on pipe and tank firefighting and isolating and removing the source. Structural fires are more contained, but people can be trapped inside the structure, thus requiring coordinated search and rescue techniques. Additionally, the materials used to fight fires differ. Municipal firefighters primarily use water to fight Class A fires (wood/paper),

whereas the primary tool for industrial firefighters is foam which is used to fight class B and C fires (flammables/electrical).

Municipal firefighters have a broader scope of job duties. As job duties are more narrow for industrialized firefighters, there may be more opportunity for accommodation of various medical conditions.⁶ There is a different skill set as well between the two.⁸ Municipal firefighters are trained in rapid intervention and team concepts, accountability systems, and search procedures. Industrial firefighters deal more with confined space rescue and must have knowledge of the properties of pressurized gas fires and large scale flammable liquids. Additionally, industrial firefighters are frequently trained in high-angle rescue. Table 1 describes other differences that may exist.

The literature review, completed survey, and interviews, found industrial fire brigades to be as diverse as the companies for which they work. While the scope of duty may be limited to handling fire extinguishers—with anything larger requiring a municipal fire department response—more typically, industrial fire brigades are highly structured with command and control personnel, officers, and front-line firefighters. As the fire chief is usually not actively engaged in fighting the fire, he/she is not subject to the same physical demands—not classifying the chief as a firefighter violates the closely-knit nature of the firefighting team. However, for purpose of classifying physical demands, we use the term “firefighters” for those actively and offensively engaged in the isolation and removal of the fire source.

HOW CAN CARDIOVASCULAR FITNESS FOR DUTY BE BEST DETERMINED FOR INDUSTRIAL FIREFIGHTERS?

In 2007, a National Institute for Occupational Safety and Health (NIOSH) alert, addressed the risks of firefighters dying from preventable cardiovascular disease (CVD).⁹ Later research supported NIOSH’s findings.^{10–16} A 2014 study found 45% of on-duty firefighter deaths were caused by CVD.¹⁷ Nearly all firefighter cardiac deaths involve coronary risk factors—predictors include previous coronary heart disease (CHD), hypertension, and smoking.^{10,18,19} Metabolic syndrome, psychological stress, noise, sleep disorders, smoke, carbon monoxide, cyanide, and thermoregulatory stress are also associated with cardiovascular risk/fitness in firefighters.^{20–24} Studies have demonstrated that more than 40% of firefighters exceed low CHD risk.¹⁸ Volunteer firefighters have the highest risk for cardiac fatality and CHD.^{25,26}

TABLE 1. General Differences between Industrial and Community Firefighters

	Industrial (Excluding Incipient Firefighters)	Community (Volunteer/Municipal/Woodlands)
Training		
Candidate ability test	–	++
Trained as medic/paramedic	+	+++
Training with mock fires	+++	+
Knowledge		
Properties of large scale flammable liquids	+++	+
Plant operations	+++	–
Trenching and shoring	++	+
Confined space	+	+++
Search and rescue	+	+++
Accountability systems (locate firefighters)	+	+++
Calls		
Calls, high volume team/dept.	Under 100 per year	Over 1000 per year
Calls, low volume team/dept.	One per 6 mo	One per week
Repeat responses in 24 hrs	0	+++
Medical emergency	Vast majority	2 out of 3
First due in (first on scene)	6+, often all in	3–6 escalating rapidly as needed
Some distance to get to equipment	Yes	No
Environment		
Remote	+	–
Marine	+	–
Industrial	+	–
Woodlands	–	+
High rise	–	+
Interior	–	+
Gear		
Bunker gear, boots, Glove helmet, SCBA	+	+
Chemical suit/decontamination	++	+ (special teams)
High temperature suit	++	+ (special teams)
Strength		
Upper body work	++	+++
Lower body work	+++	+++
Pulling more hoses, heavier	+++	++
Carrying hoses up, dragging injured	+	++
Ladder raising	+	++
Work on uneven surface	+	++
Lift heavy objects off trapped	+	++
Climb hillsides/shoveling	–	++ (wildland)
Chopping with axe	–	++
Crawling	–	++
Equipment		
Extinguishers	++	+
Hose, number and size	+++	+
Foam	+++	+
Fixed monitors	+++	–
Hydrants, ladder, pumper	+	+
Hand tools, Jaws of life	+	+++
Fire type		
Chemical	+++	+
Explosive	+++	+
Fuel	+++	+
Electrical	+ (high voltage)	++
Wood	–	+++
Hazards		
Metal structures	++	+
Noise (pressurized fuels)	++	–
Electric	+ (high voltage)	+
Carcinogens	+ (ex. asbestos)	+ (ex. Benzopyrene)
Chemicals (HCN, HCL, solvents)	++	+

Key: +++ much more; ++ common; + occasional or present; – rare or absent; SCBA, self-contained breathing apparatus.

Sources: 2015 industrial fire chief interviews, Brayton Fire Training Field, College Station, TX; NFPA 1582 list of essential job tasks; and International Fire Chiefs Association's guide to implementing NFPA 1582.

Industrial firefighting statistics and smaller industrial fires are frequently not public knowledge.²⁷ Firefighting statistics include deaths attributed to fire response

that may occur days after the events, and it is even more doubtful such information is made available related to industrial fire response. In the absence of complete data,

industrial firefighters may have similar demographic and cardiovascular risks as volunteer community firefighters. The survey conducted by the Task Force assessed

health risks of male industrial firefighters who self-reported their height, weight, and waist circumference. Based upon a National Institute of Health risk table,²⁸ 90% were found to have increased, high, very high, or extremely high risk for type 2 diabetes, hypertension, and CHD.

Recent biomonitoring of industrial firefighters has demonstrated high peak aerobic demands in industrial live fire simulations (Glencross PM, Turner D. Physiologic Demands of Industrial Firefighting Simulations; 2016. Unpublished manuscript). Firefighting tasks require similar burst and sustained aerobic demands as required in residential firefighting.^{29–31} In the clinical setting, aerobic capacity can be determined using the gold standard of metabolic testing or estimated using treadmill testing using conversion tables. Aerobic capacity and fitness are also good predictors of cardiac abnormalities and risk.^{32–35} Maximal treadmill tests (to voluntary exhaustion) should be used to estimate peak aerobic fitness. Submaximal stress tests in firefighters, such as the Gerkin (WFI treadmill protocol) have been shown to overestimate VO_2 max and thus underestimate potential cardiac risk and aerobic fitness.^{36–39} Maximal heart rate formulas and steady-state assumptions used to calculate VO_2 max tables contribute to inaccurate estimates with submaximal testing. For example, if 40 mL/kg/min (11 METS) is used as a fitness threshold for firefighters, submaximal stress testing leads to dangerous and erroneous results by suggesting that 17% to 30% of unfit firefighters are aerobically fit.^{37,39}

Elevated body mass index (BMI) was thought to be due to many firefighters' higher muscle mass.⁴⁰ However, this has been disproven.^{41–43} While in other populations, obesity and body composition do not correlate with exercise tolerance, there is evidence it does in firefighters.^{44,45} Furthermore, in firefighters, an elevated BMI limits the benefits of exercise.³²

Autopsy studies have linked cardiomegaly and left ventricular hypertrophy (LVH) to sudden cardiac death in firefighters. As a result, there have been calls for increased early detection by echocardiogram because ECG alone is a specific test, but lacks sensitivity.^{46–50} Smoking, CHD, hypertension, and obesity are all linked to LVH in firefighters.⁵¹

Besides clinic-based testing, industrial fire teams can also develop other tests to demonstrate aerobic fitness. Several studies have demonstrated success in matching timed performance in the field, (running, running with weights) with measured VO_2 max in the laboratory, thereby constructing simple to administer field tests.^{31,52–54} Some of these studies used absolute VO_2 max cut-offs. When the measured task requires the carriage of body weight, use of a relative VO_2 max

goal should be considered. In other words, the same firefighting task may have higher aerobic demands in an individual having a higher body weight and wearing a larger size of wet clothing. Fitness training programs are strongly recommended for firefighters although few industrial fire teams participate in formal programs.^{4,32,55,56}

IS PSYCHOLOGICAL STRESS DIFFERENT FOR STRUCTURAL VERSUS INDUSTRIAL FIREFIGHTERS?

There is extensive literature addressing the psychological stressors of firefighting especially in first responders; however, the literature is devoid of specific studies in industrial firefighters. The Task Force's survey identified a cohort of industrial firefighters who had also served as community firefighters. The perception of this cohort was that the stress of industrial firefighting was greater than what they had experienced as community firefighters (Turner D, Cathcart D, Glencross PM. ORCHSE Survey of Industrial Firefighters; 2016. Unpublished manuscript). Psychological stress in the industrial firefighter is a recognized gap in the literature, and as such represents an opportunity for research to assess the extent and impact it may have on the health and safety of these individuals.

ARE TOOLS CURRENTLY USED TO DETERMINE FITNESS FOR DUTY USEFUL?

Firefighters are universally subject to a high level of physical and mental stresses during their jobs. Industrial firefighters, like their municipal counterparts, share similar demanding environmental factors, but as has been suggested, fatality rates are likely much higher in the setting of industrial fires.⁵⁷ Proper tools to assess fitness-for-duty are therefore important to ensure firefighters are properly equipped to handle the dangers of the job while minimizing casualties. While studies regarding firefighter fitness exist, very few focus on industrial departments.

Prospective firefighters must pass physical assessments prior to service. Several different methods currently assess fitness, but there are no universally accepted standards across all organizations. NFPA publishes several codes and standards by which many groups abide. (NFPA 1583 provides fitness guidelines that incorporate measures of aerobic capacity, flexibility, muscular and endurance, and body composition testing as part of a regular fitness regimen.⁵⁸) The Candidate Physical Ability Test (CPAT) is widely used simulation test for which contains eight firefighting tasks that mimic real-life scenarios: (1) stair

climb; (2) hose drag; (3) equipment carry; (4) ladder raise and extension; (5) forcible entry; (6) search; (7) rescue; and (8) ceiling breach and pull.⁵⁹

Industrial fire brigades may have their own internal guidelines for fitness-for-duty measurements. Royal Dutch Shell's global requirements specify minimum fitness and health indicators for firefighters and rescue teams. These include testing of visual acuity, blood pressure, the cardiovascular system, and breathing apparatus usage.⁶⁰ Occupational Safety and Health Administration (OSHA) standards require passing a trade test, determined by local jurisdictions, which varies by specific roles, but may include elements found in the CPAT such as ladder climb, victim rescue, and equipment carry.⁶¹

Bhojani developed a cumulative fitness score ranging from 0 to 140 based on seven parameters of fitness to determine overall industrial firefighter fitness-for-duty evaluation.⁶² These factors included: (1) resting heart rate; (2) diastolic blood pressure; (3) aerobic capacity; (4) body fat percentage; (5) muscular strength; (6) muscular endurance; and (7) flexibility. All seven components correlated significantly with the total fitness score even after controlling for age and experience.

Assessments such as CPAT are geared toward all firefighters across industries, as the exercises are applicable in many types of situations. OSHA 1910.156(c)(2) lists national training and educational programs specifically for the oil refinery industry, such as those at Texas A&M University and Lamar University, after which all similar programs should be modeled.⁶³ NFPA has standards that describe general job performance requirements for industrial firefighters.⁶⁴ It is unclear whether additional established tools are necessary specifically for industrial firefighters. A study comparing industrial firefighters to municipal firefighters in California found that "despite programmatic differences, these departments demonstrated similar, relatively high degrees of physical fitness and similar blood lipid concentrations, blood pressure levels, and cardiac risk factors."⁶⁴ However, the industrial firefighter sample was small ($n = 17$). Additional studies examining physiological characteristics of industrial firefighters based on NFPA standards would help determine if it would be beneficial to implement additional tools specific to industrial firefighting.

WHAT PREVENTIVE INTERVENTIONS ARE AVAILABLE AND HOW EFFECTIVE ARE THEY?

Recognizing that cardiovascular disease and sudden cardiac death represent the

single most frequent cause of duty-related fatalities in firefighters, an important question to be considered as part of this review is, “What preventive interventions are available and how effective are they in reducing cardiovascular risk?” As with other research questions there is a gap in the literature specifically addressing industrial firefighters. Therefore, this review addresses the effectiveness of wellness/fitness programs to reduce risk factors for cardiovascular disease and to improve cardiovascular capacity in the workforce in general and in municipal firefighters specifically as a potential surrogate for industrial firefighters.

There is abundant evidence in the literature to support the beneficial effects of diet and exercise to prevent cardiovascular disease. The landmark RAND study of US employers validated the effectiveness of workplace wellness programs to influence beneficial changes in behavioral risk factors for cardiovascular disease.⁶⁵ The study reported statistically significant and clinically meaningful improvements among participants of wellness programs in exercise frequency, smoking behavior, and weight control.

A 2013 study sampled fire departments that had implemented medical and fitness programs comparable to those recommended in the Fire Service Joint Labor Management Wellness Fitness Initiative (WFI).⁶⁶ WFI recommendations included:

1. NFPA 1582 compliant annual medical physical examinations to all fire service personnel
2. A designated health/fitness coordinator
3. Peer fitness trainers
4. Time for physical training/working out while on duty for all fire service personnel

The researchers identified 10 fire departments generally meeting the WFI recommendations and a closely matched number of fire departments that did not meet the criteria. There were 1002 male firefighters in the study; 522 in fire departments aligned with WFI recommendations, and 480 not meeting recommended criteria. The study found that firefighters in departments meeting WFI criteria were less likely to be obese (adjusted odds ratio [AOR]=0.58; 95% confidence interval [CI]=0.41 to 0.82), more likely to meet endurance capacity standards for firefighting (AOR = 5.19; 95% CI = 2.49 to 10.83), and have higher estimated VO₂ max (40.7 ± 0.6 vs 37.5 ± 1.3 for firefighters in standard departments; *P* = 0.001). However, studies have found that fewer than 20% of US municipal fire departments routinely engage in fitness programs and periodic fitness-testing.³²

Delisle et al³⁶ proposed the potential of a peer-mentor intervention to modify fitness outcomes in firefighters designated as high risk for cardiovascular disease via a 3-month, high-intensity, pilot study. The small cohort firefighters (*n* = 29) demonstrated the effectiveness of this social cognitive theory approach to increase VO₂ max and decrease body fat percentage versus a control group. This difference persisted at 1-year follow-up. The significance of this pilot study could be that it shows the importance of involving firefighters in the planning, implementation, and evaluation process—although, intervention costs were not considered.

The only long-term, randomized, prospective trial in municipal firefighters that was identified in the literature review was the PHLAME (Promoting Healthy Lifestyles: Alternative Models’ Effects) Firefighter Study.⁶⁷ This trial focused on nutrition, physical activity, and the maintenance of a healthy bodyweight. A team-centric intervention group, an individual-focused motivational interviewing intervention, and a control group receiving usual care were followed for 7 years. The interventions did not result in significant nor sustainable improvements in weight, cardiopulmonary fitness levels, or healthy physical activity behaviors.

Therefore, if industrial firefighters are better represented by US employees, will they be more likely to respond favorably to worksite wellness programs as supported by the RAND study; conversely, will they be more resistant to workplace interventions as suggested by the PHLAME study of municipal firefighters? It is evident from this review that inadequate attention has been given to industrial firefighters as a group; their demographic make-up and overall health status remains virtually unknown. It is, therefore, not possible at this time to predict the outcome of workplace interventions for this group of professionals. The implication is that studies directed toward industrial firefighters will be necessary to elucidate the best approach to achieving sustained changes in diet and exercise behaviors to reduce the risk of cardiovascular disease.

HOW DO US LAWS IMPACT FITNESS-FOR-WORK DECISIONS?

This document does not address Americans with Disabilities Act (ADA) or Genetic Information Nondiscrimination Act (GINA) considerations. The evaluating physician needs to review federal and state laws and regulations related to safety-sensitive positions, post-offer evaluation, medical accommodations, applicability of paid

versus volunteer firefighting, public safety exemption for periodic examinations of employees, and family health inquiries related to cardiovascular disease risk. The safety-sensitive nature of firefighting duties and the volunteer status of firefighters in many industrial settings potentially allow for comprehensive annual fitness-for-duty assessments. It is important, however, that knowledgeable stakeholders, including legal and human resources, be consulted in the construct of the physical assessment process to ensure compliance with all relevant laws.

DISCUSSION

The Task Force has undertaken an extensive literature review in an attempt to provide an evidence-based guidance for assessing the fitness-for-duty of an industrial brigade firefighter. This was initiated due to the exclusion of industrial fire brigades from the very comprehensive NFPA 1582 medical standard and the paucity of information on the medical clearance process contained in the NFPA 600 standard, which is specifically intended to cover industrial fire brigades. The lack of specific studies of industrial firefighters within the medical literature excluded the possibility of an evidence-based guidance document. There was, however, sufficient information to draw some preliminary conclusions and to formulate a series of recommendations in terms of potential research opportunities as well as considerations for best practice approaches to the assessment of the cardiovascular fitness of industrial firefighters.

In general, there are many similarities between industrial fire brigades and community firefighters; however, there are distinct differences with industrial firefighters. These differences potentially place the industrial firefighter at an elevated risk by virtue of the greater hazards and more diverse fire types they encounter, their more rigorous training demands, the greater levels of mental stress, and a demographic of chronic disease, deconditioning, and obesity. Based upon responses from industrial firefighters surveyed by the Task Force, 90% had increased, high, very high, or extremely high risk for diabetes, hypertension, or coronary heart disease. How best to quantify this risk within the setting of a fitness-for-duty evaluation is a main objective of this Task Force. Risk calculators have not been validated in industrial firefighters, and the commonly used sub-maximal stress tests overestimate VO₂ max and as a result underestimate potential cardiac risk and aerobic fitness.

A number of fitness-for-duty methodologies exist across industry, and many do adopt the NFPA 1582 standard to assess industrial firefighters. The presumption that

any firefighter activities with similar peak demands will lead to similarly observed adverse cardiac events suggests that industrial firefighters should be screened aggressively for cardiac disease and aerobic capacity. One major problem with the NFPA 1582 standard is that the recommended approach to cardiovascular screening is sub-maximal stress tests (Gerkin WFI treadmill protocol) which, as noted, overestimate VO_2 max and, if utilized in this setting, may lead to the erroneous medical clearance of aerobically unfit individuals for firefighting duties. Several studies exist that determine best practices for firefighters' fitness-for-duty, but none focuses on industrial firefighting, likely due to a lack of assessment tools specifically developed for industry.

Preventive measures to reduce cardiovascular disease risk factors and improve aerobic fitness are critically important for industrial firefighters; unfortunately, no studies exist within this population to assess the effectiveness of any intervention. The only long-term, randomized, prospective trial in municipal firefighters identified in this review did not result in significant nor sustainable improvements in weight, cardiovascular fitness levels, or healthy physical activity behaviors.

RECOMMENDATIONS

Until additional specific medical information on industrial firefighters is available, the Task Force makes the following recommendations:

1. Reference NFPA 1582 for all aspects of the physical assessment with the exception of cardiovascular fitness.
2. Implement maximal exercise tolerance tests for the cardiovascular assessment since aerobic capacity and fitness has shown to be a good predictor of cardiac abnormalities as well as risk. Commonly used submaximal stress tests in firefighters, such as the Gerkin (WFI treadmill protocol) overestimate VO_2 max.
3. Eliminate use of submaximal stress testing as it has been shown to dangerously overestimate cardiovascular fitness.
4. Encourage additional follow-up research in the following areas:
 - a. Develop a careful analysis of job tasks with consideration for shift-work, overtime, physical requirements for the tasks, as well as the psychological, cognitive, and environmental stressors for industrial firefighters.
 - b. Conduct studies at local sites or across a particular industrial sector (eg, oil refineries, chemical manufacturing, etc) to evaluate the

nature of the jobs and to assess whether fitness practices specific to those areas are valid and beneficial towards completing the job of an industrial firefighter in a safe and efficient manner.

- c. Investigate the demographic makeup of industrial firefighters and include an assessment of their cardiovascular risk profile, biometric data, and overall health.
- d. Conduct studies to identify barriers to implementing sustainable health promotion programs in industrial firefighters and assess the effectiveness of worksite programs in reducing the incidence of cardiovascular disease.
- e. Additional studies examining physiological characteristics of industrial firefighters based on NFPA standards would help determine if it will be beneficial to implement additional tools and/or tests specific to industrial firefighting.
- f. Develop and validate fitness-training programs for industrial firefighters.

In summary, industrial brigade firefighters share many characteristics with municipal firefighters, but their unique job responsibilities and the physical/mental demands under which they work have not been adequately studied. The Task Force found gaps in the medical literature as to demographic makeup, behavioral risk factors, and burden of chronic disease, effectiveness of preventive interventions to enhance wellness through risk factor reduction and aerobic fitness, and the proper methodology for a fitness-for-duty assessment. Due to these gaps, the Task Force will undertake the development of a guidance document for industrial firefighters emulating the model provided by the current ACOEM Guidance for the Medical Evaluation of Law Enforcement Officers (LEO).⁶⁸

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**Appendix 1: ORCHSE Survey
of Industrial Firefighters.
Turner D, Cathcart D,
Glencross PM (2016).
Unpublished Manuscript**

- 1) How old are you (years)? 21 to 25; 26 to 30; 31 to 35; 36 to 40; 41 to 45; 46 to 50; 51 to 55; 56 to 60; 61 to 65; 66 to 70; 71 to 75.
- 2) Are you: male; female.
- 3) What is your height? Feet; inches.
- 4) What is your weight (pounds)?
- 5) What is your waistband circumference (belt size in inches)?
- 6) How many days per week do you exercise on average? Aerobic (defined as at least run 15 min/walk 10,000 steps/bike 30 min/swim 30 min/other 15 min); non-aerobic (defined as walking or similar activities that do not meet aerobic thresholds); resistance (defined as weight lifting /strengthening).
- 7) Where have you exercised in the last 3 months? In company gym; not in company gym but on company grounds; outside of company; part of a fire team exercise program.
- 8) How many years total have you been a firefighter?
- 9) What type of fire fighter are you now? (Check all that apply) industrial fire team; volunteer community firefighter; paid community firefighter; medic in community; military/other firefighter.
- 10) How would you characterize your role on the industrial fire team (select all that apply) fight fire in full bunker gear/SCBA; command and control only; support role only (ex. engineer/logistics/operations); medic; other.
- 11) What level of industrial responder best describes what you do? Incipient responder; exterior firefighter; structural firefighter; exterior/structural firefighter; Hazmat operations level (defensive); Hazmat technician (offensive).
- 12) What were the medical requirements to be cleared for the industrial fire team? (Select all that apply) Note from personal physician only; company physical examination required; functional capacity evaluation; treadmill or step testing; none.
- 13) How often are you required to be medically cleared for the industrial fire team? Annually; periodically, based upon my age; periodically, based upon my personal health risk factors; other
- 14) Which industrial fire team activities have you participated in over the last 3 months and how many hours would you estimate total? Response to actual fires; response to non-fire emergency; hands on training/drills; offsite firefighter school; classroom training; competitions.
- 15) If you have not had to respond to actual fires in the last 3 months—have you responded in the last year? Yes; no. If yes, how many times?
- 16) Do you have experience as a community firefighter? Yes; no. If yes, identify type of community: urban; suburban; rural; agricultural; combination.
- 17) If you have experience as a community firefighter, do you consider industrial firefighting to have easier physical demands; the same physical demands, just less frequent; harder physical demands.
- 18) If you have experience as a community firefighter, do you consider industrial firefighting to be more, the same or less physically stressful; mentally stressful; dangerous; training
- 19) Why do you participate in the industrial fire team? (Rank all the following and add other as appropriate.) Pay; teamwork; pride; part of job; challenge; other
- 20) Provide any additional comments regarding industrial firefighting.