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Summary of recommendations from the National Institute for Occupational Safety and Health Fire Fighter Fatality Investigation and Prevention Program, 2006–2014

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ABSTRACT

Introduction: The NIOSH Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) conducts independent investigations of selected fire fighter line-of-duty deaths (LODD) and offers recommendations to prevent similar deaths. The purpose of the current study was to provide information on more recent FFFIPP recommendations and to determine if recommendations have changed over time. *Methods*: Fatality investigations completed from 2006 to 2014 were selected for this study with recommendations being assigned into twelve major categories when possible. The most frequently occurring recommendations were then rank ordered overall and then by medical and traumatic fire fighter LODD. *Results*: There were 1,067 total recommendations made in the published fire fighter investigative reports for both medical and trauma-related fire fighter fatalities for the period 2006–2014. Of these, 784 (73%) could be placed within one of the 12 categories noted previously. The top 10 recommendation categories overall were: 1. Medical screening, 2. Fitness and wellness program, 3. Training, 4. Medical clearance, 5. Standard Operating Procedures/Standard Operating Guidelines (SOPs/SOGs), 6. Incident command, 7. Strategy and tactics, 8. Communications, 9. Personal protective equipment and 10. Staffing. *Conclusions*: The leading recommendations from the NIOSH FFFIPP medical investigations between 2006 and 2014 did not change compared to those made between 1998 and 2005, with the exception of the addition of "medical clearance for duty". There were changes for the traumatic injury leading recommendations for 2006–2014, with the major change being "training", which was the leading FFFIPP recommendation for traumatic injuries for this time period. *Practical applications*: The intent of the FFFIPP is to influence fire departments and fire fighters to critically assess and evaluate situations/circumstances similar to those identified by NIOSH investigations and implement the recommendations offered to prevent additional fire fighter fatalities.

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1. Introduction

During the late 1970's and 1980's, fire fighter fatalities averaged over 125 deaths per year (NFPA, 2017). Only in the 1990's and later did fire fighter fatalities begin to sporadically fall below 100 deaths annually (NFPA, 2017; USFA, 2015). Due in part to these high numbers of fatalities, Congress, in 1998, provided funding to the National Institute for Occupational Safety and Health (NIOSH) to implement a fire fighter safety initiative. This initiative was to address the national problem of work-related fire fighter fatalities that were due to the high-risk situations encountered at incident scenes.

With this funding, NIOSH created the Fire Fighter Fatality Investigation and Prevention Program (FFFIPP). The FFFIPP conducts independent investigations of selected fire fighter line-of-duty deaths and offers recommendations to prevent similar deaths. The FFFIPP is a public health program and does not enforce compliance with state or federal occupational safety and health standards, nor does it determine fault or place blame on fire departments or fire fighters. The sole purpose for conducting the fire fighter fatality investigations is to determine the cause(s) or reason(s) for the fatality(ies) and offer recommendations to prevent similar incidents (NIOSH, 2017a).

Incidents selected for investigation are identified by using the FFFIPP Prioritization Guideline decision flow chart (NIOSH, 2009). Investigation priorities are useful in order to maintain focus of the program and target investigations on the most important issues of the fire service. Investigation priorities are periodically revised in response to changing or emerging hazards and/or in response to fire service stakeholder input. Investigations are voluntary and include record reviews (law enforcement, medical examiner, fire fighter training requirements, departmental policy and procedures, building construction information, and

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apparatus or vehicle maintenance/inspection records), incident site inspection, and, if appropriate, inspection of turnout gear and self-contained breathing apparatus. Interviews are conducted with fire department members and other on-scene witnesses. This information results in a FFFIPP published investigation report describing the events leading to the fatality, and recommendations to prevent incidents of a similar nature. Since the program's inception, approximately 40% of fire fighter deaths (both trauma and medical) have been investigated.

A prior effort to summarize recommendations from NIOSH fire fighter fatality investigations was reported in a NIOSH numbered publication covering the years 1998–2005. This report looked at the top 10 recommendations over this eight-year period (Ridenour et al., 2008). From 1998 through 2005, the FFFIPP identified 863 fire fighters who died in the line of duty, excluding the 343 fatalities in the World Trade Center tragedy in 2001. The FFFIPP investigated 335 of the fatal incidents that resulted in 372 (43%) fire fighter fatalities. The investigations encompassed a variety of circumstances such as cardiovascular-related deaths, motor-vehicle incidents, structure fires, diving incidents, and electrocutions. Fatalities were investigated in career, volunteer, and combination departments in both urban and rural settings in the United States. The leading recommendations reflect the types of incidents investigated and may not apply to all the fire fighter deaths during that time. For the investigations conducted by NIOSH, the leading causes of death included sudden cardiac events (143), motor-vehicle incidents (58), asphyxiation (57), non-motor vehicle trauma (26), burns (24), drowning (8), other medical conditions (7), electrocution (6), heat stress (2), sarcoidosis – cardiac involvement (2), and other traumatic injury (2).

For these fatalities, most of the recommendations for medical-related fatalities addressed: (a) annual medical screenings for every fire fighter to assess fitness for duty and (b) fitness and wellness programs that enable members to develop and maintain a level of health and fitness to safely perform their assigned functions. For the trauma-related fatalities, the leading recommendations addressed: (a) standard operating procedures/standard operating guidelines (SOPs/SOGs) which are specific directions for common situations fire personnel will face. They provide all members of a fire department with a common set of enforceable rules to be followed by everyone. SOPs/SOGs should be reviewed, evaluated, and updated periodically and all personnel must be aware of, trained in, and observe the fire department's SOPs/SOGs that should guide actions of fire fighters in all types of incidents; (b) communications which encompasses the exchange of information that allows the department to respond appropriately to calls and keep personnel safe on the fireground or incident scene; (c) incident command which has the overall responsibility of managing the response to an incident. The proper utilization and operation of incident command is paramount in keeping personnel safe and resources effectively engaged in the task at hand and includes life safety, incident stabilization, and property conservation; (d) motor vehicle (MV) recommendations addressing vehicle operators and passengers (fire service vehicles and privately owned vehicles responding to an incident) along with personnel working at MV incident scenes and generally encompass prudent driving, seat belt use, vehicle maintenance and operator training; (e) personal protective equipment (PPE) is vital to protect fire fighters when operating on the job and includes the proper use of self-contained breathing apparatus (SCBA) devices (self-contained underwater breathing apparatus [SCUBA] for those departments with dive teams), personal alert safety system (PASS) devices, proper retirement of fire fighter turnout gear and wearing and use of proper PPE at MV incidents (retroreflective vests, red wands, flares, cones, etc.); (f) strategies and tactics which includes strategies such as switching from offensive to defensive tactics, continually evaluating risk versus gain during the incident, and using firefighting tactics such as ventilation, water supply, exit routes, safety line use, and searches; (g) rapid intervention teams (RITs) who are a dedicated crew of fire fighters assigned for rapid deployment to rescue lost or trapped members; and (h) staffing which addresses issues of having an adequate number of fire fighters, adequate deployment procedures and team continuity (Ridenour, et al., 2008).

Another study (Kunadharaju, Smith, and Dejoy, 2011) analyzed NIOSH fire fighter fatality investigation reports from 2004 to 2009. The FFFIPP reports for this time period produced a total of 1,167 recommendations. Thirty-five high frequency recommendations were derived from the total set: 6 related to medical fatalities and 29 to injury-related or trauma fatalities. The researchers mapped these high frequency recommendations onto the major operational components of firefighting using a fishbone or cause–effect diagram. Over 70% of the 30 fire fighter organizational recommendations were categorized within personnel and incident command. Root cause techniques suggested four higher order causes: under-resourcing, inadequate preparation for/anticipation of adverse events during operations, incomplete adoption of incident command procedures, and sub-optimal personnel readiness. This methodology of identifying high frequency recommendations, mapping them onto the major operational firefighting components and applying root cause techniques is another way in which to utilize the recommendations from the FFFIPP reports.

The purpose of the current study was to provide information on more recent FFFIPP recommendations and to determine if recommendations have changed over time.

2. Methods

Fatality investigations completed from 2006 through 2014 were selected for this study. Incident dates covered by the investigations ranged from May 2004 through November 2014.

A database of information included in FFFIPP reports has been maintained by the NIOSH Division of Safety Research (DSR) since 2009. Recommendations from FFFIPP reports were assigned into major categories within the database (Table 1). Other variables of interest were captured, including fire department characteristics, event characteristics, victim information, and information on contributing factors. The 2009–2014 NIOSH database of FFFIPP investigation report recommendations were analyzed along with the information from the publically available NIOSH FFFIPP website (NIOSH, 2017b, 2017c). Reports were categorized and analyzed by: medical or traumatic fatality; type of fire department – volunteer, career or combination (e.g., both career and volunteer fire fighters); cause and nature of death; and state of occurrence. Since data for the time period 2006–2008 were not in the NIOSH DSR database, FFFIPP investigative reports were reviewed by two independent coders and the recommendations were assigned to the major categories identified in Table 1.

NIOSH investigated 40% of the fatal fire fighter incidents for 2006–2014 which means the types of incidents investigated may not be representative of all fire fighter line-of-duty-deaths during this time period, especially since investigations are prioritized using the FFIPP Prioritization Guideline decision flow chart. For the trauma-related investigations, the top level priority is an incident incurring multiple fatalities followed by structure fires and motor-vehicle incidents; since these are priorities for investigation, they likely would have impacted the

Table 1
FFFIPP report recommendation categories.

1. Fitness and wellness program
2. Medical screening
3. Medical clearance
4. SOPs/SOGs
5. Communications
6. Incident command
7. Motor vehicle
8. Personal protective equipment
9. Strategy and tactics
10. Rapid intervention team
11. Staffing
12. Training

type of recommendations made. For example, since investigation of structure fires has priority over motor-vehicle incidents, recommendations addressing fire suppression strategy and tactics are more likely to be found in the database than those addressing motor-vehicle operation.

Medical clearance is an additional recommendation from the medical-related investigation reports in this analysis and involves whether the fire fighter can perform the essential job tasks without risking their lives, their co-workers' lives, or those of the civilians they are sworn to protect. Training was listed as one of the recommendation elements in 2009 in the NIOSH DSR database in order to capture the required training that is needed for firefighting duties; for the 1998–2005 analysis, training was grouped together with SOPs as a recommendation element.

3. Results

Between 2006 and 2014, there were 742 fire fighter line-of-duty deaths (NFPA, 2017). During the same time period, NIOSH initiated 282 fire fighter investigations with 279 investigations (99%) completed and 3 reports pending (NIOSH, 2017b, 2017c). These 279 completed investigations captured 306 (41%) of the 742 fatalities reported by NFPA. The fatalities were categorized by the Nature and Cause of the event (Table 2). The Nature of injury or medical event identifies the principal physical characteristic(s) of the injury or medical event while the Cause of injury or medical event is the term that is used to describe what caused the injury. For Nature, the leading events were: (a) heart-related events (126), followed by; (b) internal trauma events (47); (c) Other Non-medical (36); (d) asphyxiation (34); (e) burns (24); and (f) crushed events (22). The (a) Cause of the fatality was also categorized with the leading cause of death being medical events (134), followed by; (b) motor vehicle events (38), including vehicle collision/rollover and struck by vehicle; (c) caught/trapped (30); (d) Other (29); (e) collapse (23); and (f) becoming lost or disoriented (17) [Table 2]. Some of the largest identified areas within the Other categories were "smoke inhalation" (18) and blunt force trauma (14). Totals in the text may be more than what is listed in Table 2 because the "Other" categories (Other Medical, Other Non-Medical, and Other) had descriptions which, in some instances, allowed inclusion into more specific categories. These investigations also identified 220 non-fatal injuries that required hospital treatment incurred by other on-duty fire fighters at the same events where a fatality occurred (NIOSH, 2017b).

Investigations were conducted in 43 different states. The seven states where investigations were not conducted included Delaware, Hawaii, Maine, Montana, Nebraska, Oregon, and Wyoming. For those states where an investigation occurred, 7 had 10 or more investigations: Texas, New York, Pennsylvania, California, Illinois, North Carolina, and Ohio.

The NIOSH fire fighter investigations were closely apportioned between medical and trauma fatalities at 138 and 125, respectively. The investigations were also closely divided between volunteer fire departments (38%) and career fire departments (44%), with 41 (16%) being combination departments and 5 (2%) being an "Other" category (fire academy, inmate, paid on-call, federal wildland, or full/part-time). All "Other" cases that were investigated were medical. There were trauma fatalities in the "Other" category, but due to the FFFIPP Prioritization Guideline decision flow chart, none were selected for investigation. When categorized by "medical" or "trauma" fatality investigation, the percent distribution remained similar (Table 3).

The most common traumatic fatality events investigated were motor vehicles (23%), which included vehicle collision/rollover (13%) and struck by vehicle (10%). The second leading cause was caught/trapped (16%), followed by structure collapse (13%), and lost/disoriented (10%). These four categories accounted for 58% of the trauma investigations and 63% of the investigated trauma fatalities. For medical fatality investigations, 89% were cardiovascular related.

There were 1,067 total recommendations made in the published fire fighter investigative reports for both medical and trauma-related fire fighter fatalities for the period 2006–2014. Of these, 784 (73%) could be placed within 1 of the 12 categories from Table 1. The top 10 recommendation categories overall were:

1. Medical screening.
2. Fitness and wellness program.
3. Training.
4. Medical clearance.
5. Standard Operating Procedures/Standard Operating Guidelines (SOPs/SOGs).
6. Incident command.
7. Strategy and tactics.
8. Communications.
9. Personal protective equipment.
10. Staffing.

In reviewing the recommendations by type of fatal event (i.e., medical vs. trauma), the leading recommendation categories for medical fatalities were (Table 4):

1. Medical screening.
2. Fitness and wellness.
3. Medical clearance for duty.

The leading recommendation categories for both medical and traumatic injury investigations were compared between the years 1998–2005 and 2006–2014. For 2006–2014 traumatic fatalities, the leading recommendation categories were (Table 4):

1. Training.
2. Standard operating procedures.
3. Incident command.
4. Strategy and tactics.

Table 2
Frequency of Nature and Cause of FFFIPP fatalities, 2006–2014.

Nature of fatality		Cause of fatality	
Coronary heart disease	106	Medical event triggered by physical exertion	134
Cardiac conduction problem	5	Medical event NOT triggered by physical exertion	
Heart valve abnormality	3	Vehicle collision/rollover (MVA)	21
Cardiomyopathy	8	Struck by vehicle	17
Aortic aneurysm	1	Lost/disoriented	17
Hyperthermia	3	Caught/trapped	30
Other medical	17	Collapse	23
Internal trauma	47	Struck by (Other)	10
Asphyxiation	34	Fall	13
Burns	24	Electrocution	5
Crushed	22	Drowning	2
Other non-medical	36	Other	29
Unknown	1	Unknown	5
Total	306	Total	306

Table 3
Distribution of fire fighter investigations by fatality type and fire department type.

Fatality type	Fire department type				
	Volunteer (%)[a]	Paid/career (%)[a]	Combination (%)[a]	Other (%)[a]	Total
Trauma	50 (19%)	55 (21%)	20 (8%)	–	125
Medical	51 (19%)	61 (23%)	21 (8%)	5 (2%)	138
Total	101	116	41	5	263

[a] Percentages are of total investigations and percentages are rounded to the nearest whole number.

Table 4
Rank order comparison of leading FFFIPP recommendations for 1998–2005 and 2006–2014.

Recommendation	1998–2005	2006–2014
Medical fatalities		
Medical screening	1	1
Fitness and wellness	2	2
Medical clearance for duty		3
Traumatic fatalities		
Training		1
Standard operating procedures	1	2
Incident command	3	3
Strategy and tactics	6	4
Communication	2	5
Motor vehicles	4	6 (tied)
Personal protective equipment	5	6 (tied)
Staffing	8	8
Rapid intervention team	7	9

5. Communication.
6. Motor vehicles (tied).
7. Personal protective equipment (tied).

4. Discussion

Sudden cardiac deaths were the largest share of deaths among on duty fire fighters for every year of this study except 2013, when it was "internal trauma/crushing" (Fahy, Leblanc, and Molis, 2015). Even though there has recently been a downturn in the number of sudden cardiac deaths among on-duty fire fighters, it has continued to account for the largest share of fire fighter fatalities, highlighting the need for adoption of medical-related recommendations (Kales, Soteriades, Christoudias, and Christiani, 2003; Proudfoot, Hales, Truttmann, and Gugliolmo, 2006; NIOSH, 2007; Smith, Barr, and Kales, 2013; Staley, Weiner, and Linnan, 2011). It's not surprising that for the cardiovascular-related fatality investigations the recommendations encompass medical aspects (Kales, Soteriades, Christophi, and Christiani, 2007; Farioli et al., 2013).

Fitness and wellness programs attempt to reduce modifiable coronary risk factors while individualized programs for high-risk workers appear to be the most promising (Ridenour et al., 2008; Soteriades, Smith, Tsismenakis, Baur, and Kales, 2011). Medical clearance procedures recognize the strenuous and physically demanding aspects of being a fire fighter and attempts to lessen the risk for those who work in this challenging environment by having a medical professional periodically assess the fire fighter's health. Medical screening involves medical testing to find undiagnosed medical conditions such as hypertension (measure blood pressure), heart disease (exercise stress tests, electrocardiograms, etc.) and cancer tests (e.g., blood in stool for colon cancer, mammograms for breast cancer, PAP smears for cervical cancer, etc.). Medical screening can be used to assess applicants prior to joining the fire service and also as an ongoing process once in the fire service. Medical clearance involves having a medical professional determine whether the fire fighter can perform the essential job tasks without risking the lives of themselves, their co-workers, or the civilians that fire fighters have sworn to protect.

The traumatic injury fatalities have multiple causes and thus are dispersed among several different areas as indicated by the nature of injury, cause of injury, and the resulting recommendations. For the 1998–2005 analysis, training was grouped together with SOPs as a recommendation element. In 2009, training was recognized as one of the recommendation elements in the NIOSH DSR database in order to capture the required training that is needed for firefighting duties; for 2006–2008, the FFFIPP investigative reports were reviewed by two independent coders and the recommendations were assigned to the major categories identified in Table 1, of which "training" was one. The top three leading recommendations made by traumatic FFFIPP reports for 2006–2014 were "training" followed by SOPs/SOGs with incident command third; for 1998–2005 the leading recommendation was SOPs, which would've included training followed by communication and then incident command recommendations. It could be that by grouping "training" and "SOP" together in the earlier analysis, it was masking the effect that training had as a recommendation but that can't be known for certain unless a reanalysis is done. For 2006–2014 compared to 1998–2005, communication moved three places (lower) in the rankings; everything else that changed moved by two places except PPE which changed by one place (Table 4).

5. Conclusion

The medical investigations accounted for a slight majority of the FFFIPP investigations. The leading recommendations from the NIOSH FFFIPP medical investigations between 2006 and 2014 did not change compared to those made between 1998 and 2005, with the exception of the addition of "medical clearance for duty." There were changes for the traumatic injury leading recommendations for 2006–2014, with the major change being "training," which was treated as a separate recommendation from 2006 forward and being identified as the leading FFFIPP recommendation for traumatic injuries for this time period. Strategy and tactics moved upward two places and motor vehicles and rapid intervention team recommendations moved downward two places. Communication recommendations moved downward three places for 2006–2014 compared to 1998–2005; staffing recommendations remained the same.

The intent of the FFFIPP is to influence fire departments and fire fighters to critically assess and evaluate situations/circumstances similar to those identified by NIOSH investigations and implement the recommendations offered to prevent additional fire fighter fatalities. The high number of medical events with the subsequent recommendations underscore the continued need for better medical screening, implementation of fitness and wellness programs, and medical clearance for duty for personnel of fire departments. Identifying the major traumatic recommendations most frequently made highlights the continued need for fire departments to implement training programs and standard operating procedures addressing incident command, fire suppression strategy and tactics, communication, motor-vehicle operation, use of PPE, staffing, and rapid intervention teams. Only through continued vigilance and addressing hazards facing fire fighters will we be able to see decreased fatalities to this workforce.

Declarations of interest

None.

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