

Surveillance of Traumatic Firefighter Fatalities: An Assessment of Four Systems

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ABSTRACT

Objectives. Firefighters regularly respond to hazardous situations that put them at risk for fatal occupational injuries. Traumatic occupational fatality surveillance is a foundation for understanding the problem and developing prevention strategies. We assessed four surveillance systems for their utility in characterizing firefighter fatalities and informing prevention measures.

Methods. We examined three population-based systems (the Bureau of Labor Statistics' Census of Fatal Occupational Injuries and systems maintained by the United States Fire Administration and the National Fire Protection Association) and one case-based system (data collected through the National Institute for Occupational Safety and Health Fire Fighter Fatality Investigation and Prevention Program). From each system, we selected traumatic fatalities among firefighters for 2003–2006. Then we compared case definitions, methods for case ascertainment, variables collected, and rate calculation methods.

Results. Overall magnitude of fatalities differed among systems. The population-based systems were effective in characterizing the circumstances of traumatic firefighter fatalities. The case-based surveillance system was effective in formulating detailed prevention recommendations, which could not be made based on the population-based data alone. Methods for estimating risk were disparate and limited fatality rate comparisons between firefighters and other workers.

Conclusions. The systems included in this study contribute toward a greater understanding of firefighter fatalities. Areas of improvement for these systems should continue to be identified as they are used to direct research and prevention efforts.

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Occupational surveillance, the ongoing, systematic collection, analysis, interpretation, and dissemination of data, serves as the foundation for improving worker safety.¹ Surveillance data are generally used to characterize and describe the magnitude and rate of a problem, monitor trends, identify situations that contribute to high numbers or rates, and help guide prevention efforts. Population-based surveillance attempts to identify all incidents, or all incidents occurring among a predefined group.² Case-based surveillance identifies specific incidents of interest, with certain cases selected for follow-up based on the potential to yield new insights, or as sentinel events indicative of failures of current prevention efforts.³⁻⁵

Firefighters are one population of U.S. workers that receives particular attention from a surveillance perspective. Approximately 100 firefighters die from on-duty incidents annually.⁶ Because firefighting is a demanding, dangerous, and complex job in which workers regularly respond to hazardous situations that put them at risk for traumatic and medical incidents, analysis of surveillance data for this worker group can lead to prevention efforts directed at mitigating occupational hazards.

Currently, surveillance of U.S. firefighter fatalities is conducted through four systems. Three are population-based: the Census of Fatal Occupational Injuries (CFOI) developed and maintained by the U.S. Bureau of Labor Statistics (BLS); a system maintained by the United States Fire Administration (USFA); and a system maintained by the National Fire Protection Association (NFPA), a nongovernmental entity. The National Institute for Occupational Safety and Health (NIOSH) maintains a case-based system, the Fire Fighter Fatality Investigation and Prevention Program (FFFIPP).

We examined the four systems (CFOI, USFA, NFPA, and FFFIPP) for their utility in characterizing traumatic firefighter fatalities and their potential for informing prevention strategies. We identified similar variables from the systems for fatal traumatic incidents occurring from 2003 to 2006 and examined variables unique to each system.

METHODS

On-duty fatalities among firefighters can be classified into two categories: traumatic and medical. Traumatic fatalities are characterized by an extrinsic force causing injury. These extrinsic forces may be physical or environmental (e.g., high temperatures), or involve poisonous or toxic effects (e.g., carbon monoxide exposure).⁷ Medical fatalities frequently manifest as

heart attacks or strokes. We limited analysis to traumatic fatalities only, which represent roughly 50% of on-duty deaths of firefighters annually.⁶

Information for each of the four data systems is summarized in the Figure, including goals, data sources, and inclusion and exclusion criteria. Categories for certain variables within each data system have been grouped for comparison.

CFOI data system

The BLS conducts population-based surveillance of traumatic occupational fatalities for all worker groups through CFOI (Figure). CFOI does not include data on medical-related fatalities that occur at work. Collected by state agencies and compiled by the BLS, CFOI includes data from all 50 states and the District of Columbia for all fatal, traumatic occupational injuries identified and confirmed using federal, state, and local document sources. For a fatal work injury to be included in CFOI, the decedent must have been employed and engaged in legal work activity or present at or traveling between work sites as a job requirement.⁸ CFOI includes fatalities to volunteer workers if they were performing the same duties or functions as paid employees.⁹

We conducted analyses of CFOI data using a research file provided to the NIOSH Division of Safety Research by the BLS under a memorandum of understanding. Although CFOI data are typically reported by year of death, to be consistent with the other data sources used for this analysis, firefighter fatalities were selected if a traumatic incident occurred from 2003 through 2006 regardless of when the person died. Cases were identified using the Standard Occupational Classification (SOC) codes 33-1021 (first-line supervisors/managers of firefighting and prevention workers), 33-2011 (firefighters), 33-2021 (fire inspectors and investigators), and 33-2022 (forest fire inspectors and prevention specialists).¹⁰ From 2003 to 2006, CFOI identified traumatic incidents that led to 174 firefighter fatalities.

The BLS reports rates of worker fatalities per 100,000 full-time equivalent (FTE) workers (one FTE worker = 2,000 hours worked per year) based on hourly estimates from the Current Population Survey (CPS), the primary source of U.S. labor force statistics (Table 1). The CPS is a sample-based household survey conducted monthly by the U.S. Census Bureau for the BLS. The BLS recently moved from calculating rates for CFOI per 100,000 workers to calculating rates per 100,000 FTE as a more accurate means of assessing actual risk for workers.¹¹ Volunteer work is not routinely collected in the CPS; thus, the BLS excludes fatalities of volunteer

Figure. Characteristics of U.S. surveillance systems that include traumatic firefighter fatalities

Characteristics	Bureau of Labor Statistics Census of Fatal Occupational Injuries ^{a,b}	USFA ^c	NFPA ^d	NIOSH Firefighter Fatality Investigation and Prevention Program ^e
Goal/mission	Collect information on all fatal occupational injuries.	Identify specific problems and find solutions to reduce the number of firefighter fatalities in the future.	Measure and characterize the on-duty firefighter fatality problem in the U.S. and work to reduce fatalities through consensus codes and standards, research, training, and education.	Better define the characteristics of line-of-duty deaths among firefighters. Develop recommendations for the prevention of deaths and injuries. Disseminate prevention strategies to the fire service.
Scope	All workers in U.S.	Firefighters in U.S.	Firefighters in U.S.	Firefighters in U.S. (selected cases)
Data sources	Federal, state, and local sources including: Death certificates Workers' compensation reports Police reports News reports OSHA forms 300/301 USFA firefighter fatality notices	Public records including: Reports from fire departments Reports from NFIRS Information from state and federal agencies NIOSH Fire Fighter Fatality Investigation Reports Responses to specific data requests	Public records including: Reports from fire departments Reports from NFIRS Information from state and federal agencies NIOSH Fire Fighter Fatality Investigation Reports Responses to specific data requests	Field-based investigations Review of department records (e.g., dispatch tapes, standard operating procedures, and training records) Management and witness interviews Photographs and videos Information from state and federal agencies
Inclusion criteria	Employed workers (includes private, federal/state/local government, resident, and military) Volunteer workers Workers engaged in legal work activity	Paid and volunteer firefighters Local and municipal firefighters State, territory, and federal government fire personnel Privately employed firefighters Prison inmates serving on firefighting crews Military personnel assigned to fire-suppression activities Civilian firefighters at military installations Firefighters at U.S. territorial and overseas military installations	Paid and volunteer firefighters Local and municipal firefighters State, territory, and federal government fire personnel Privately employed firefighters Prison inmates serving on firefighting crews Military personnel assigned to fire-suppression activities Civilian firefighters at military installations	Paid and volunteer firefighters Local and municipal firefighters State and federal government fire personnel Privately employed firefighters Prison inmates serving on firefighting crews

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Figure (continued). Characteristics of U.S. surveillance systems that include traumatic firefighter fatalities

Characteristics	Bureau of Labor Statistics Census of Fatal Occupational Injuries ^{a,b}	USFA ^c	NFPA ^d	NIOSH Firefighter Fatality Investigation and Prevention Program ^e
Exclusion criteria	Prison workers (unless employed off premises) Military personnel killed outside of U.S. Recreational activities not required by fire department Normal commute to/from work	Recreational activities not required by fire department Normal commute to/from work	Firefighters at U.S. territorial and overseas military installations Recreational activities not required by fire department Normal commute to/from work	Military personnel Civilian firefighters at military installations Recreational activities not required by fire department Normal commute to/from work
Included work activities	Involved in operations at a fire or non-fire incident Responding to/from an incident At the fire department or facilities for work purposes Away from the fire department or facilities for work purposes (e.g., training)	Involved in operations at a fire or non-fire incident Responding to/from an incident Completing other officially assigned duties (e.g., training, maintenance, inspection) On standby duty (except at individual's home or place of business)	Involved in operations at a fire or non-fire incident Responding to/from an incident Completing other officially assigned duties (e.g., training, maintenance, inspection) On standby duty (except at individual's home or place of business)	Involved in operations at a fire or non-fire incident Responding to/from an incident Completing other officially assigned duties (e.g., training, maintenance, and inspection) On standby duty (except at individual's home or place of business)
Types of fatalities	Traumatic	Traumatic/medical	Traumatic/medical	Traumatic/medical
Data availability	Online charts, tables, and query systems Research files per request and approval	Online Fire Fighter Fatality Notices Online annual reports Research files per request and approval	Online annual reports Special analyses per request	Online case reports

^aDepartment of Labor, Bureau of Labor Statistics (US). BLS handbook of methods: chapter 9: occupational safety and health statistics. Washington: BLS; 2008.

^bDepartment of Labor, Bureau of Labor Statistics (US). Census of Fatal Occupational Injuries (CFOI): definitions. 2008 [cited 2009 Oct 27]. Available from: URL: <http://www.bls.gov/iif/oshc/def.htm>

^cDepartment of Homeland Security, Fire Administration (US). Firefighter fatalities in the United States in 2008. Emmitsburg (MD): Federal Emergency Management Agency (US); 2009.

^dFahy RF, LeBlanc PR, Molis JL. Firefighter fatalities in the United States—2009. Quincy (MA): National Fire Protection Association; 2010.

^eNational Institute for Occupational Safety and Health (US). Fire Fighter Fatality Investigation and Prevention Program: program description [cited 2009 Sep 22]. Available from: URL: <http://www.cdc.gov/niosh/fire/implweb.html>

USFA = United States Fire Administration

NFPA = National Fire Protection Association

NIOSH = National Institute for Occupational Safety and Health

OSHA = Occupational Safety and Health Administration

NFIRS = National Fire Incident Reporting System

Table 1. Annual rates of firefighter fatalities: U.S., 2003–2006^a

Incident year	Census of Fatal Occupational Injuries			United States Fire Administration			National Fire Protection Association					
	Traumatic fatalities	FTE workers ^b	Fatalities per 100,000 FTE workers	Traumatic fatalities associated with a fire incident	Total annual fire incidents ^c	Fatalities per 100,000 fire incidents	Traumatic fire ground fatalities	Total annual structure fires ^d	Fire ground fatalities per 100,000 structure fires	Traumatic fatalities among career and volunteer firefighters	Number of municipal career and volunteer firefighters ^e	Fatalities per 10,000 career and volunteer firefighters
2003	28	399,581	7.01	33	1,584,500	2.08	9	519,500	1.73	40	1,096,900	0.36
2004	23	416,449	5.52	28	1,550,500	1.81	14	526,000	2.66	42	1,100,750	0.38
2005	18	388,506	4.63	22	1,602,000	1.37	10	511,000	1.96	33	1,136,650	0.29
2006	28	400,014	7.00	32	1,642,500	1.95	14	524,000	2.67	34	1,140,900	0.30

^aAnnual rates of traumatic fatalities calculated by the National Institute of Occupational Safety and Health

^bFTE worker estimates come from: Department of Labor, Bureau of Labor Statistics (US). Current population survey, 2003–2008 (microdata files) and labor force, employment, and unemployment from the current population survey. In: BLS handbook of methods. Washington: BLS; 1992.

^cBased upon: National Fire Protection Association. National Fire Experience Survey [cited 2010 Aug 6]. Available from: URL: <http://www.nfpa.org/itemDetail.asp?categoryID=955&itemID=23850&URL=Research/Fire%20statistics/The%20U.S.%20fire%20service>

^dBased upon: National Fire Protection Association. The U.S. fire problem [cited 2010 Jun 15]. Available from: URL: <http://www.nfpa.org/itemDetail.asp?categoryID=953&itemID=23072&URL=Research/Fire%20statistics/The%20U.S.%20fire%20problem>

^eBased upon: Karter MJ Jr, Stein GP. U.S. Fire Department profile through 2008. Quincy (MA): National Fire Protection Association; 2010.

FTE = full-time equivalent

workers in rate calculations. Rates calculated for this article by NIOSH also exclude fatal events involving volunteer firefighters.

USFA data system

USFA conducts population-based surveillance of both traumatic and medical on-duty firefighter fatalities (Figure). When a fatality occurs, USFA receives voluntary notification from the victim's department, other federal agencies, and fire service organizations. USFA also follows up on news reports of firefighter fatalities. After initial notification, USFA contacts the victim's department to confirm the incident and to obtain the department's incident report and other incident-related information. Data from the department and other sources are compiled in a single firefighter fatality data system.¹²

We obtained USFA firefighter fatality data files for this analysis. Traumatic fatalities were identified where the nature of fatal injury variable included asphyxiation, burn, crush, drowning, electrocution, trauma, fall, heat exhaustion, or violence. When the nature of the injury was noted as "other," we examined the case description to determine if the fatality was indeed traumatic. USFA identified 454 traumatic and medical-related fatalities resulting from incidents occurring from 2003 through 2006; 207 (46%) were traumatic and were analyzed for this study.

USFA reports rates of traumatic and medical fatalities per 100,000 fire incidents using estimates from the National Fire Experience Survey (NFES) (Table 1).¹³ The NFES is a sample-based fire department survey conducted annually by the NFPA. USFA excludes non-fire incidents (e.g., training incidents) in rate calculations. Rates calculated for this article by NIOSH were specific to traumatic fatalities and excluded medical deaths otherwise included in USFA reported rates. The NIOSH analyses also excluded non-fire incidents for rate calculations.

NFPA data system

The NFPA also conducts population-based surveillance of both traumatic and medical on-duty firefighter fatalities (Figure).¹⁴ While the NFPA uses different data collection forms, the NFPA and USFA use similar data collection methods and sources to collect similar types of data. A primary difference is that USFA's inclusion criteria were broadened in 2003 by the Hometown Heroes Act,¹⁵ which has resulted in USFA capturing a larger number of heart attack and stroke cases than the NFPA. When discrepancies occur for cases not captured as a result of the Hometown Heroes Act,

USFA and NFPA staff attempt to reconcile differences (Personal communication, Rita F. Fahy, NFPA, November 2009).

The NFPA identified cases for inclusion in this study. As with the USFA data, we identified traumatic fatalities by examining data for the nature and description of fatal injury variables. The NFPA provided aggregated data for several variables, while we used the NFPA data to calculate rates. The NFPA identified a total of 384 firefighter fatalities resulting from incidents occurring from 2003 through 2006; 199 (52%) were traumatic and were included in this study.

The NFPA reports rates of traumatic and medical fatalities per 100,000 structure fires and per 10,000 career and volunteer firefighters based on estimates from the NFES (Table 1). Fatalities occurring away from the fire ground (e.g., responding to and from an incident) were not included in the structure fire rate calculations. The firefighter population-based rates included only municipal career and volunteer firefighters and excluded federal, state, and privately employed firefighters. Rates calculated for this article were specific to traumatic fatalities and did not include medical deaths that would be included in NFPA reported rates. Otherwise, we used the same calculation methods used by the NFPA.

FFFIPP data system

NIOSH maintains a case-based surveillance system of firefighter fatalities through the FFFIPP, a program established in 1998 that involves on-site investigations of selected firefighter on-duty deaths. These investigations are used to formulate recommendations for preventing future deaths and injuries.¹⁶ NIOSH receives voluntary notification of fatal incidents from USFA, fire departments, fire service organizations, and news sources. Generally, decisions to investigate incidents are made based on assessment of the potential to identify emerging risks and investigator workload. Beginning in 2007, NIOSH posted guidelines for prioritizing investigations. For traumatic fatalities, priority has been given to investigating incidents involving multiple fatalities, structure fires, and motor vehicles.¹⁷

Investigation findings are summarized in published narrative case reports and entered as standardized data into databases. Separate databases are maintained for traumatic and medical fatalities. The FFFIPP investigated a total of 150 traumatic and medical fatalities that resulted from incidents occurring from 2003 through 2006; 73 (49%) of these fatalities were traumatic and were analyzed for this study.

RESULTS

The number of traumatic firefighter fatalities that resulted from incidents from 2003 through 2006 differed among the three population-based surveillance systems (Table 2). Numbers based on the USFA and NFPA data were identical or differed by a count of one for most years. The largest difference was seen in 2005. At least four of the nine fatalities in 2005 were specifically excluded from the NFPA based on its collection criteria. Both the USFA and NFPA identified more cases overall compared with CFOI.

Decedent characteristics

The four systems had similar demographic measures (e.g., gender and age) but had different measures of victims' experience (Table 2). The USFA, NFPA, and FFFIPP all recorded tenure of total firefighting service. While tenure as a firefighter may approximate experience, the diversity of exposures and variable workloads encountered by firefighters complicates this measurement. Tenure with employer at time of incident was recorded by CFOI and FFFIPP, but this information may also be complicated by the fact that employers may change throughout a career. Furthermore, about half of the CFOI cases were missing data for this variable.

Every system recorded the employment status of firefighters (Table 2); however, the variable differed across data systems. CFOI defines volunteers as people not receiving any compensation or pay, while the other three data systems include firefighters receiving some type of compensation for firefighting among those identified as volunteers. Compared with the population-based data, the FFFIPP included a larger proportion of fatalities involving career firefighters.

Every data system included data for occupation and rank. CFOI classified decedents using SOC codes that were not used by the other data systems. The NFPA and FFFIPP classified occupation by rank. Because of differences in rank at the federal, state, and municipal levels, the NFPA measures of rank included only municipal career and volunteer firefighters. USFA recorded rank, but data were not categorized.

The data systems differed in their utility for identifying type of employer. Standardized data for industry were available only from CFOI, which uses the North American Industry Classification System. Most victims were classified in the Fire Protection group. Those classified in the Agriculture, Forestry, Fishing, and Hunting sector, which includes support activities for forestry, may reflect firefighters involved in fighting wildfires. Data recorded by CFOI and NFPA for ownership and type of employer may be more useful than data recorded for the industry sector because victims'

employers are categorized to more specific entities including municipal departments, state/federal land management agencies, and industrial fire departments. Although the USFA recorded department names, this information was not categorized. Likewise, FFFIPP recorded employer type but did not categorize these data.

Incident characteristics

All data systems demonstrated some utility in identifying multiple fatality incidents. Although not shown, multiple fatality incidents accounted for 21% to 25% of fatalities recorded by the population-based systems and 19% of FFFIPP-investigated fatalities. BLS reporting restrictions designed to ensure nondisclosure of confidential records limited the ability to report CFOI data on specific multiple fatality incidents.

Every system recorded data describing the nature of the traumatic fatality. Differences in categorization and data use requirements for CFOI required grouping of several categories (Table 3). All data systems identified nonspecific trauma/crushed most often. Furthermore, the three population-based data systems used different classification schemes to characterize the cause or types of events associated with fatalities, but all three systems indicated that events involving motor vehicles accounted for the largest share of fatal injuries. Although similar information from the FFFIPP data was not available, individual investigation reports included detailed discussions of fatality causes and contributing factors.

The USFA, NFPA, and FFFIPP all included data characterizing firefighting activity at the time of incident. Most fatalities occurred during emergency duty, particularly at the scene of a fire. For the USFA, NFPA, and FFFIPP data systems, a larger portion of fatalities occurred during on-scene fire duties for career firefighters as compared with volunteers. For volunteer firefighters, a greater percentage of fatalities occurred during response/travel to a call as compared with career firefighters. Similar information from CFOI was not available.

Safety measures

The USFA and FFFIPP data systems included information on whether recognized safety measures were in place at the time of the incident. While such information can help inform prevention recommendations, the utility of the information currently available is limited. The FFFIPP included data on the existence of standard operating procedures (SOPs) or guidelines that help to ensure that departments follow consistent procedures. Although this variable provided an indication

of whether the SOPs addressed any one of nine general safety measures (e.g., SOPs for responding in emergency vehicles, such as seat belt use), the variable

did not address the SOPs' applicability to any specific incident, whether the SOPs were being followed at the time of the incident, or the completeness or quality of

Table 2. Annual distribution and decedent characteristics of traumatic firefighter fatalities: U.S., 2003–2006

Characteristics	CFOI N (percent)	United States Fire Administration N (percent)	NFPA N (percent)	Fire Fighter Fatality Investigation and Prevention Program N (percent)
Total	174	207	198	73
Incident year				
2003	48 (27.6)	59 (28.5)	59 (29.8)	26 (35.6)
2004	42 (24.1)	50 (24.2)	49 (24.7)	15 (20.6)
2005	34 (19.5)	48 (23.2)	39 (19.7)	18 (24.7)
2006	50 (28.7)	50 (24.2)	51 (25.8)	14 (19.2)
Gender				
Male	163 (93.7)	194 (93.7)	186 (93.9)	67 (91.8)
Female	11 (6.3)	13 (6.3)	12 (6.1)	6 (8.2)
Age group (in years)				
≤19	9 (5.2)	13 (6.3)	11 (5.6)	2 (2.7)
20–24	22 (12.6)	24 (11.6)	23 (11.6)	10 (13.7)
25–34	40 (23.0)	46 (22.2)	43 (21.7)	19 (26.0)
35–44	49 (28.2)	50 (24.2)	50 (25.3)	22 (30.1)
45–54	27 (15.5)	38 (18.4)	35 (17.7)	11 (15.1)
55–64	15 (8.6)	27 (13.0)	26 (13.1)	8 (11.0)
≥65	12 (6.9)	9 (4.4)	10 (5.1)	1 (1.4)
Tenure of service (in years)				
≤1	NA	41 (19.8)	23 (11.6)	11 (15.1)
2–5	NA	57 (27.5)	47 (23.7)	19 (26.0)
6–10	NA	16 (7.7)	23 (11.6)	3 (4.1)
11–20	NA	57 (27.5)	46 (23.2)	29 (39.7)
>20	NA	36 (17.4)	38 (19.2)	11 (15.1)
Not reported	NA	0 (0.0)	21 (10.6)	0 (0.0)
Tenure with employer (in years)				
≤1	21 (12.1)	NA	NA	7 (9.6)
2–5	16 (9.2)	NA	NA	14 (19.2)
6–10	17 (9.8)	NA	NA	8 (11.0)
11–20	16 (9.2)	NA	NA	19 (26.0)
>20	18 (10.3)	NA	NA	7 (9.6)
Not reported	86 (49.4)	NA	NA	18 (24.7)
Employment status (CFOI) ^a				
Work for pay compensation	97 (55.8)	NA	NA	NA
Volunteer	77 (44.3)	NA	NA	NA
Employment status ^a				
Career	NA	59 (28.5)	56 (23.3)	42 (57.5)
Volunteer/paid on-call/part-time (paid)	NA	100 (48.3)	93 (47.0)	28 (38.4)
Wildland full-time/part-time/contract	NA	48 (23.2)	47 (23.7)	3 (4.1)
Other (inmate crew/industrial)	NA	NA	2 (1.0)	NA
Standard occupational classification				
Firefighters	141 (81.0)	NA	NA	NA
Supervisors/inspectors/ investigators/specialists	33 (19.0)	NA	NA	NA
Rank ^b				
Firefighter	NA	NA	107 (71.8)	45 (61.6)
Company officer	NA	NA	25 (16.8)	21 (28.8)
Chief officer	NA	NA	17 (11.4)	7 (9.6)

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Table 2 (continued). Annual distribution and decedent characteristics of traumatic firefighter fatalities: U.S., 2003–2006

Characteristics	CFOI N (percent)	United States Fire Administration N (percent)	NFPA N (percent)	Fire Fighter Fatality Investigation and Prevention Program N (percent)
Industrial classification				
Public administration sector				
Fire protection	146 (83.9)	NA	NA	NA
Other	^c	NA	NA	NA
Agriculture, forestry, fishing, and hunting sector				
Support activities for forestry	24 (13.8)	NA	NA	NA
Other	^c	NA	NA	NA
Employer				
Local government	144 (82.8)	NA	149 (75.3)	NA
Federal or state government	22 (12.6)	NA	48 (24.2)	NA
Private ownership	8 (4.6)	NA	1 (0.5)	NA

^aCategorization of employment status differed across data systems. Categories were grouped where necessary for this analysis.

^bNFPA totals for rank include only municipal career and volunteer firefighters.

^cData do not meet publication guidelines.

CFOI = Census of Fatal Occupational Injuries

NFPA = National Fire Protection Association

NA = not available

the SOPs. For 30% of the investigated incidents, this variable was recorded as unknown or not available. Information on the applicability and quality of SOPs is generally available in FFFIPP investigation reports.

Examples of other safety measure variables collected by both the USFA and FFFIPP include whether an incident management system (a command structure in which an incident commander has overall responsibility for directing operations and ensuring firefighter safety) was used; whether an incident safety officer, whose primary responsibility is overseeing firefighter safety, was on scene; and whether fatally injured firefighters had received various levels of certification (a measure for minimal levels of training). For each of these measures, variable quality may have been affected by applicability (e.g., an incident management system might not be involved in a motor vehicle incident), interpretation (e.g., the ability to distinguish between an effective or ineffective incident management system), and/or availability of information (i.e., there were a considerable number of cases in which the information was unknown or not available).

Compared with the three population-based systems, a unique aspect of the FFFIPP is the use of detailed case investigation reports that have resulted in hundreds of recommendations for preventing traumatic firefighter injuries and fatalities. A recent NIOSH publication

grouped these recommendations into eight broad categories: SOPs, communications, incident command, motor vehicles, personal protective equipment, strategies and tactics, rapid intervention teams, and staffing.¹⁸ A newly implemented revision of the FFFIPP data system now includes variables for recording recommendations based on these categories.

Fatality rates

Table 1 presents fatality rates by year from 2003 through 2006. Inclusion criteria for the numerator and denominator used to calculate rates from each system make inter-system comparisons impossible. However, the routine availability of data on an annual basis facilitates monitoring rates over time; no clear trends were seen from the limited numbers of years included in this analysis.

Because the CFOI system includes data for all worker groups, a comparison of firefighter traumatic fatality rates with those of the general worker population and specific occupations is possible. However, such comparisons should be undertaken very cautiously. As illustrated in Table 1, the firefighter traumatic fatalities included in CFOI rate calculations are only a portion of the firefighter traumatic fatalities each year and do not include volunteer firefighters, who clearly outnumber compensated firefighters.

DISCUSSION

In this study, we found that the four systems each included valuable data to describe firefighter fatalities. To meet individual agency goals, the systems employed different methods for counting and characterizing cases and for calculating fatality rates, which limited some system comparisons. Understanding how differences affect counts and impact rates is important when assessing traumatic firefighter fatalities.

The number of traumatic firefighter fatalities identified by the three population-based systems differed slightly, with CFOI identifying fewer cases. Some discrepancies among case counts may be the result of different inclusion criteria. Without more detailed case

comparisons, it is difficult to determine why the number of traumatic fatalities may differ for each system.

Fatality rates are important for assessing the level of risk faced by firefighters and comparing risk levels with those of other workers. A strength of the different systems is that rates are calculated using both population and incident denominator data. Rates based upon population denominator data can provide an overall picture of trends in firefighter fatalities as an occupational group, and by certain demographic factors such as age,¹⁴ and may facilitate comparisons with workers in other occupations. Incident-based denominator data allow for greater understanding of situational risks. For example, one study demonstrated that declines in structure fire-related fatalities coincided with declines

Table 3. Selected characteristics of traumatic firefighter fatalities: U.S., 2003–2006

<i>Characteristics</i>	<i>Census of Fatal Occupational Injuries N (percent)</i>	<i>United States Fire Administration N (percent)</i>	<i>National Fire Protection Association N (percent)</i>	<i>Fire Fighter Fatality Investigation and Prevention Program N (percent)</i>
Total	174	207	198	73
Nature of fatal injury				
Trauma/crushed	111 (63.8)	145 (70.1)	137 (69.1)	36 (49.3)
Asphyxiation	28 (16.1)	32 (15.5)	24 (12.1)	19 (26.0)
Burns	25 (14.4)	22 (10.6)	21 (10.6)	11 (15.1)
Other (drowning, electrocution, heat exhaustion, hypothermia)	10 (5.7)	8 (3.9)	16 (8.1)	7 (9.6)
Cause of fatal injury				
Vehicle collision	NA	98 (47.3)	89 (44.9)	NA
Caught/trapped/collapse	NA	53 (25.6)	47 (23.7)	NA
Struck by object	NA	25 (12.1)	27 (13.6)	NA
Fall	NA	18 (8.7)	12 (6.1)	NA
Lost	NA	6 (2.9)	9 (4.5)	NA
Other	NA	7 (3.4)	14 (7.1)	NA
Event/exposure				
Transportation accidents				
Highway accidents	67 (38.5)	NA	NA	NA
Pedestrian struck by vehicle	13 (7.5)	NA	NA	NA
Other	12 (6.9)	NA	NA	NA
Fires				
Structure fire	39 (22.4)	NA	NA	NA
Wildland/outdoor fire	13 (7.5)	NA	NA	NA
Struck by or caught in (object, equipment, or collapsing materials)	13 (7.4)	NA	NA	NA
Falls	6 (3.4)	NA	NA	NA
Other	11 (6.3)	NA	NA	NA
Emergency duty				
Yes	NA	150 (72.5)	153 (77.3)	62 (84.9)
No	NA	57 (27.5)	45 (22.7)	11 (15.1)
Type of duty				
On-scene fire	NA	74 (35.8)	75 (37.9)	39 (53.4)
Responding	NA	51 (24.6)	49 (24.7)	18 (24.7)
Training	NA	21 (10.1)	16 (8.1)	7 (9.6)
On-scene non-fire	NA	12 (5.8)	11 (5.6)	2 (2.7)
Returning	NA	12 (5.8)	18 (9.1)	2 (2.7)
Other	NA	37 (17.9)	29 (14.6)	5 (6.9)

NA = not available

in the number of structure fires over a 23-year period; however, the rate of fatalities remained steady and the rate of traumatic fatalities inside structures increased.¹⁹ Because the methods used to calculate fatality rates vary, comparisons between systems are difficult, if not impossible.

It is difficult to compare firefighter population estimates with those of workers in occupations where volunteer work is rare. Because detailed data on volunteer work are only sporadically collected by the CPS,²⁰ reliable population estimates of all firefighters are unavailable. The NFPA annually reports population estimates of municipal career and volunteer firefighters, and average length of work week at career departments.²¹ However, hours-based employment data are not comparable with estimates derived for workers in other occupations. While there have been attempts to estimate comparable hours-based employment data for firefighters,²² data collection efforts of this type are not currently implemented on a large scale, or in a manner that facilitates comparisons between career and volunteer firefighters, or with workers in other occupations. Improved methods for counting the firefighter population are needed to provide for more accurate and consistent rate calculations.

Although we included data from the FFFIPP in this study, the FFFIPP was not designed to be generalizable; it was designed to provide more detail and insight than is available from population-based systems. The program's investigations can further knowledge gained through the population-based systems. For example, FFFIPP investigations on structure fire-related incidents complemented NFPA analyses demonstrating a rise in structure fire-related traumatic fatality rates, despite advances in protective equipment and training.¹⁹ Fire scene incidents represent a growing threat to firefighter safety, and the more detailed investigations conducted through the FFFIPP may help identify risk factors and promising prevention measures to mitigate this threat.

FFFIPP investigations can also serve to identify emerging risks. For example, a series of investigations conducted through the FFFIPP led to the identification of a problem with the Personal Alert Safety System (PASS) device, a safety device worn by firefighters in hazardous situations that sounds an audible noise when a firefighter is not moving or is in distress. After NIOSH investigated multiple incidents in which the device was reported to be barely audible or inaudible, further testing confirmed deficiencies in performance. This finding led to changes in the NFPA 1982 (standard on PASS), upgrading the requirements for PASS devices to be certified.²³ In this situation, NIOSH identified

a hazard that would otherwise not have been identified by the population-based surveillance systems, and action was taken to remedy the hazard.

An overriding purpose of surveillance systems is to monitor progress. While this study compared and contrasted characteristics and available data, it did not assess the impact of these surveillance systems on firefighter safety. Ultimately, impact on safety is what is most important, but it is conceptually difficult to determine.²⁴ However, we do have anecdotal evidence of the impact that these systems can have in improving firefighter safety. For example, data from CFOI, USFA, and NFPA all highlight the substantial proportion of firefighter fatalities associated with motor vehicles, and FFFIPP case reports note when lack of seat belt use contributes to fatalities.^{12,14,18} These reports and the death of an unbuckled firefighter who fell from a fire truck led to the development of the National Fire Service and Emergency Medical Services (EMS) Seat Belt Pledge, which asks all firefighter and EMS personnel to wear a seat belt when in a fire department vehicle and to ensure that other passengers wear seat belts.²⁵ Many fire service organizations advocate for widespread adoption of the Seat Belt Pledge, and some departments have had 100% participation.²⁶ The longstanding problem of motor vehicle crashes, as measured by surveillance systems coupled with case-based reports and the precipitating firefighter fatality, has led to thousands of fire service personnel adopting an important life-saving measure. Although there are many other anecdotal examples, research to more systematically document the impact of surveillance data use is encouraged.

Limitations

This study had several limitations. First, while general comparisons of the data systems were made based upon overall numbers, variables included, and case-inclusion criteria, we could not assess specific case differences. An agreement between NIOSH and the BLS prohibited us from comparing case-specific data with data from other sources. Thus, we were unable to match cases from the four data systems to identify case inconsistencies or specific cases that were missed by the individual data systems.

Second, as with most surveillance systems, it was also not possible to assess or compare the direct impact that these systems have on preventing or reducing firefighter deaths. However, as indicated previously, and in an evaluation of the FFFIPP,²⁶ there are specific examples of data findings contributing to new or modified work practices, procedures, or standards.

CONCLUSIONS

Surveillance of firefighter fatalities is important for understanding and reducing fatal incidents. An accurate count of fatalities is important in understanding the magnitude of the problem, while fatality rates allow for relative comparisons of risk. Having detailed information on circumstances is a crucial step toward identifying risk factors and developing prevention efforts.²⁷ This study suggests that the use of data from multiple systems allows researchers to compare and contrast results to improve the understanding of the risks to firefighters. The implications for public health are that each system should be fully used in a broader effort to minimize threats to firefighters' safety. Because the CFOI includes workers in all occupations, it can be used to compare firefighter fatalities with those occurring among workers in other occupations, although accurate rate comparisons are limited.

The USFA and NFPA data systems can be used to identify and study detailed characteristics of firefighter fatalities nationally, and to understand population and incident-specific trends through reported rates. The FFFIPP data system can be used to specifically identify risks and target issues found in detailed case investigations that may not be identified otherwise. Researchers should continue to identify areas of improvement for these systems, as they are used to direct research and prevention efforts.

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