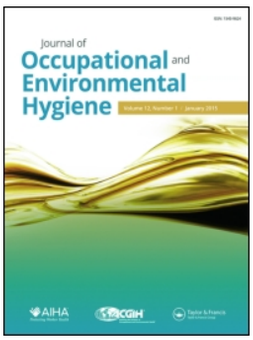

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Wildland firefighter deaths in the United States: A comparison of existing surveillance systems

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ABSTRACT

Wildland fire fighting is a high-risk occupation requiring considerable physical and psychological demands. Multiple agencies publish fatality summaries for wildland firefighters; however, the reported number and types vary. At least five different surveillance systems capture deaths, each with varying case definitions and case inclusion/exclusion criteria. Four are population-level systems and one is case-based. System differences create challenges to accurately characterize fatalities.

Data within each of the five surveillance systems were examined to better understand the types of wildland firefighter data collected, to assess each system's utility in characterizing wildland firefighter fatalities, and to determine each system's potential to inform prevention strategies. To describe similarities and differences in how data were recorded and characterized, wildland fire deaths for three of the population-based systems were matched and individual fatalities across systems were compared. Between 2001 and 2012, 247 unique deaths were captured among the systems; 73% of these were captured in all three systems. Most common causes of death in all systems were associated with aviation, vehicles, medical events, and entrapments/burnovers. The data show that, although the three systems often report similar annual summary statistics, events captured in each system vary each year depending on the types of events that the system is designed to track, such as inclusion/exclusion of fatalities associated with the Hometown Heroes Survivor Benefits Act of 2003.

The overarching and central goal of each system is to collect accurate and timely information to improve wildland firefighter safety and health. Each system is unique and has varying inclusion and exclusion criteria for capturing and tracking different subsets of wildland firefighter tasks and duties. Use of a common case definition and better descriptions and interpretations of the data and the results would help to more accurately characterize wildland firefighter traumatic injuries and illnesses, lessen the likelihood for misinterpretation of wildland firefighter fatality data, and assist with defining the true occupational injury burden within this high-risk population.

KEYWORDS
Wildland fire fatality; wildland firefighter

Introduction

Between 2001–2012, over 100 U.S. firefighter line-of-duty deaths occurred annually.[1] Firefighting is high-risk and requires considerable physical and psychological demands. Primary modes—urban/structural and non-urban/wildland firefighting—pose unique hazards to workers as suppression mechanisms and techniques differ greatly. Wildland firefighting, for example, typically requires longer (12–16+ hour days), arduous work shifts (4,000–6,000 calories expended a day) for up to 14 continuous days and is coupled with multiple environmental stressors, resulting in an occupation that is characterized as challenging and high-risk.[2]

The risk to wildland firefighters (WFFs) has increased in recent years largely due to increases in acreage burned and changes in the types of fires. In 2013, more than 4.1 million acres burned in the U.S., about twice as many as reported 40 years ago.[3] This increase is likely due to a variety of factors, including changes in climate, vegetation, snowpack, fuel conditions, and human activities.[4–6] Over the past several years, large fires have been reported in areas known as Wildland Urban Interface (WUI). The

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National Wildland Fire Coordinating Group (NWCG) defines WUI as "the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels." Although WUI comprises only 10% of all land, over 38% of U.S. homes are within these areas.[7] In 2011, the State Foresters Association estimated that over 66,000 U.S. communities were at risk because of wildland fire.[8] The economic and resource burden associated with fighting fires in these areas is increasing as more homes are built in these environments.[9]

Suppressing wildland fires in the U.S. is complex and requires a mixture of federal and state agencies, tribal governments, and local fire departments, all with different missions and responsibilities.[10] Aside from federal and state entities, others involved in wildland firefighting are often drawn from a variety of contracting agencies, prison-based crews, and military (e.g., the National Guard); the largest proportion, however, are likely volunteers from local fire departments.[10,11] The National Fire Protection Association (NFPA) estimated that in 2010, 86% of the 26,000 local fire departments with over 1.1. million firefighters had wildland fire suppression duties and many were staffed primarily by volunteers.[12]

Additionally, the NWCG estimated that the U.S. Department of the Interior (DOI) and the U.S. Department of Agriculture-United States Forest Service (USDA USFS) employed 34,000 federal workers with wildland fire suppression responsibilities in 2010 (Michelle Ryerson, National Wildfire Coordinating Group, Risk Management Committee, May 2011). The number of personnel engaged in WFF activities from other agencies (e.g., contractors, local, state, and prison-based) is generally unknown and often dictated by funding and frequency and severity of wildfires. As a result, a reliable WFF workforce estimates, similar to those collected for structural firefighters, is unknown. It is expected, however, that the number of personnel involved in wildland fire suppression will continue to grow as the frequency of large wildfires and the area burned by wildfires—particularly in the western U.S.—continues to increase.[13–15]

Most published research on WFFs has focused on monitoring acute health effects of wildland fire smoke exposure, personal energy expenditure, and physiologic response.[16–27] Additional research is needed as questions still exist regarding other types of hazards and long-term health effects that WFFs face. Currently, four population-based data systems and one case-based system captures fatality data for WFFs. The Census of Fatal Occupational Injuries (CFOI), a population-based system operated by the U.S. Bureau of Labor Statistics (BLS) collects information on all occupational fatal injuries, including WFF fatal occupational injuries. Two population-based systems, a system operated by the United States Fire Administration (USFA) and a system maintained by the National Fire Protection Association (NFPA), focus exclusively on firefighter fatalities, including WFF fatalities. The NWCG population-based system, Safety Gram, focuses exclusively on wildland firefighter fatalities. The case-based system, maintained by the National Institute for Occupational Safety and Health (NIOSH), captures select firefighter fatalities, including wildland fire-related fatalities, through investigations conducted through the Fire Fighter Fatality Investigation and Prevention Program (FFFIPP).While these systems all routinely collect data, information specific to wildland fire events is often sparse, combined with data on all U.S. firefighter deaths, and is typically limited to serious incidents and occasional near-misses.[1,28,29] In addition, the reported number and types vary,[30–34] creating challenges to accurately characterize WFF fatalities.

The purpose of this study is to better understand characteristics of workers who are fatally injured or experience a fatal medical event while performing wildland fire-related duties by examining fatalities in the five surveillance systems. This research is similar to the study conducted by Estes et al. which characterized all firefighter fatalities in 2011,[29] however, this study focused on only fatalities that occur among workers engaging in wildland firefighting activities.

Methods

Data for WFF fatality data were obtained from all four population-based data systems and the one case-based system for the years 2001–2012. Each system's case definition was used to identify fatalities associated with wildland firefighting. While not all of the systems included medical and trauma-related events, both types of events were included where possible. Traumatic-related fatalities were typically characterized as a fatal injury or disorder as the result of a single incident, event, or exposure over the course of a single shift.[35] Medical fatalities or fatal occupational illnesses that occurred while a firefighter was on-duty frequently manifested as sudden cardiac events (heart attacks) or cerebrovascular accidents (stroke). Each system is summarized below and in Table 1.

USFA surveillance system

The USFA tracks on-duty firefighter fatalities in the U.S. in their firefighter fatality data system. The USFA defines "on-duty" fatalities as those that occur at the scene of a fire or non-fire emergency, while responding to or returning from an incident and while performing other officially assigned duties. USFA also includes fatalities covered

Table 1. Data characteristics of wildland fire fighting surveillance systems.

			Database				
			United States Fire Administration	*National Wildfire Coordinating Group*	*National Fire Protection Association*	*Bureau of Labor Statistics, Census for Fatal Occupational Injuries*	*Fire Fighter Fatality Investigation and Prevention Program*
Scope	All firefighters in the U.S.		x		x	x	x
	Personnel involved in direct support of wildfire suppression including firefighting, prescribed fire, damage repair, and fire rehabilitation			x		x	
	Selected cases meeting agency criteria						x
Data Sources	Wildland fire agencies		x	x	x		x
	National Fire Incident Reporting System (NFIRS)		x	x	x		x
	Local, state and federal agencies		x	x	x	x	x
	NIOSH FFFIPP Reports		x		x		
	Public Safety Officers' Benefits Program		x	x	x		x
	Fire service organizations, individual firefighters/Incident Management Teams		x	x	x		x
	Risk Management Committee members			x			
	USFA firefighter fatality notices			x	x	x	x
	Media/news reports			x	x	x	x
	Death certificates		x		x	x	x
	Workers' compensation reports					x	
	Police reports		x		x	x	x
	OSHA forms 300/301					x	
	Field based investigations		x		x		x
	Management/witness interviews		x		x		x
	Photographs and videos		x		x		x
Inclusion criteria	Type of worker	Paid and volunteer firefighters	x	x	x	x	x
		Local and municipal firefighters	x	x	x	x	x
		State, territory, and federal government fire personnel	x	x	x	x	x
		Privately employed firefighters	x	x	x	x	x
		Prison inmates on firefighting crews	x	x	x	x	x
		Military personnel assigned to fire suppression activities	x	x	x	x	x
		Civilian firefighters at military installations	x	x	x	x	
		Firefighters at U.S. territorial and overseas military installations	x		x		
		Other emergency response/non-firefighting personnel at a wildland fire		x		x	
Inclusion criteria	Task(s) performed	All official wildland fire or non-fire duties	x		x	x	x
		Official duty at a wildland or prescribed fire incident, in mobilization or demobilization status	x	x	x	x	x
		Completing other officially assigned duties (e.g., training, public safety, maintenance, inspection)	x		x	x	
		Work capacity test[a]	x	x	x		x
		Fatalities associated with Hometown Heroes Survivor Benefits Act of 2003	x				x
		Responding to/from an incident[b]	x	x	x	x	x
		On standby duty (except at individual's home or place of business)	x		x	x	x

(Continued on next page)

Table 1. (Continued).

		Database				
		United States Fire Administration	*National Wildfire Coordinating Group*	*National Fire Protection Association*	*Bureau of Labor Statistics, Census for Fatal Occupational Injuries*	*Fire Fighter Fatality Investigation and Prevention Program*
Types of fatalities	Traumatic	x	x	x	x	x
	Medical	x	x	x		x
Data availability to researchers	Online firefighter fatality notices	x				
	Online annual reports, charts, tables and/or query system	x	x	x	x	x
	Research database per request	x	x		x	
	Special analyses per request			x		

[a] Fatalities are not considered work-related deaths unless a worker is officially employed. [b] Hometown Heroes Survivors Benefit Act of 2003 presumes that a heart attack or stroke is in the line of duty if the firefighter was engaged in non-routine stressful or strenuous physical activity while on-duty and the firefighter becomes ill while on-duty or within 24 hours after engaging in such activity.[36]

under the Hometown Heroes Survivors' Benefit Act of 2003, which states that, if the firefighter becomes ill as the result of a heart attack or stroke within 24 hr after engaging in non-routine stressful or strenuous work-related physical activity, the event is considered on-duty.[36]

The USFA compiles data related to each firefighter fatality in a database and publishes an annual summary report. All on-duty U.S. firefighter fatalities resulting from traumatic and medical events are included.

The USFA on-duty firefighter fatality MS Access database shared with the National Institute for Occupational Safety and Health (NIOSH) includes both wildland and non-wildland firefighter fatalities and 234 unique variables for each fatality. Updated on a monthly basis, the database used for this study was updated June 30, 2013. The USFA classifies WFFs as firefighters who were killed performing on-duty activities involving brush, grass, or wildland fire fighting. All wildland-related fatalities from 2001–2012 were extracted. Additionally, to verify all wildland incidents were identified, USFA annual reports from 2001–2012 were reviewed.

NFPA firefighter fatality surveillance system

The NFPA has a population-based surveillance system, Fire Incident Data Organization (FIDO), which captures all firefighter fatalities due to injuries or illnesses that occurred while the firefighter was on-duty. Similar to the USFA, the term "on-duty" refers to being at the scene of a fire or non-fire incident; responding to or returning from an incident; participating in other fire department duties, such as training, maintenance, public education, etc.; or on call or standby at a location other than a firefighter's home or place of business. The NFPA does not consider fatalities that occurred under the Hometown Heroes Survivors' Benefits Act to be "on-duty."[37]

Similar to the USFA, the NFPA compiles data related to each firefighter fatality into a surveillance system and publishes an annual summary of all on-duty U.S. firefighter fatalities, including both traumatic and medical wildland fire-related fatalities.

For this analysis, a special request was made to NFPA to provide all on-duty fatalities associated with a brush, grass or wildland fire. The NFPA provided two separate MS Excel spreadsheets containing all on-duty wildland-fire related fatalities from 2001–2012. Data included date of incident, location where incident occurred, gender, age, agency, and cause and nature of fatality. NFPA also identified whether the fatality occurred while fighting a grass/brush/wildland fire and whether it was part of a multiple fatality event.

NWCG RMC safety gram wildland fire fatalities, entrapments, and serious accident summary reporting system

The NWCG is an interagency group that provides national leadership to develop, maintain, and communicate interagency standards, guidelines, qualifications, training, and other capabilities for a variety of agencies including the USDA USFS; four DOI bureaus and agencies: Bureau of Land Management; National Park Service, Bureau of Indian Affairs, and the Fish and Wildlife Service (FWS); and the National Association of State Foresters. The NWCG Risk Management Committee (RMC) Safety Gram Fatalities, Entrapments and Serious Accident data system, or Safety Gram, tracks WFF fatalities, focusing exclusively on incidents involving emergency responders engaged in direct support of wildland fire, fire

suppression, damage repair and fire rehabilitation work. The Safety Gram reports are available on a publically accessible website. Data collected through the Safety Gram system includes fatalities that occurred during an incident, in mobilization status, demobilization status, and while training or participating in the work-capacity tests. While medical related fatalities such as heart attacks are included, fatalities related to the Hometown Heroes Survivors' Benefits Act or private citizens acting on their own behalf are typically not included by the NWCG.[38] For this study, wildland fire-related fatality reports from the Safety Gram website were reviewed for data between 2000–2012 and input into the MS Access database. No personal identifying information or demographic information was available in these reports. In selected cases, Serious Accident Investigation (SAI) Reports were reviewed to supplement/verify information from the Safety Gram reports. Produced by federal and state agencies, the SAI reports provide detailed information about select incidents.[39]

BLS CFOI

The BLS CFOI surveillance system collects details for every work-related fatality in the U.S. As a result, fatal occupational injuries that occur while suppressing a wildland fire are captured in this system. Data are collected from multiple federal, state and local sources, including death certificates, workers' compensation reports, medical examiner reports, Occupational Safety and Health Administration (OSHA) reports, and police reports. CFOI data include injury-related deaths but do not include illness-related deaths, unless the illness was caused by an injury. Thus, medical incidents among WFFs, such as heart attacks and strokes, are typically not included in CFOI.[40] Volunteers are included in CFOI if they performed the same duties as paid employees;[41] as a result, volunteer firefighters engaging in wildland fire suppression activities are included in CFOI.

Cases were identified from CFOI research files obtained through a Memorandum of Understanding between BLS and NIOSH. The CFOI includes 30 standardized data elements and two narrative incident description fields. For 2001–2002 data, the BLS used the 1990 US Census Bureau Occupation Classification (BOC) system to classify occupation and the Standard Industrial Classification (SIC) to classify industry. For data after 2002, CFOI classifies workers' occupations by using Standard Occupational Classification (SOC) codes and industry by North American Industry Classification System (NAICS). The BLS also characterizes injury characteristics based on the Occupational Injury and Illness Classification System (OIICS). The BLS revised their OIICS structure and coding 2011.[42] Personal identifying information about the decedent was not included in the research file.

For this analysis, Statistical Analysis System (SAS) version 9.3 was used to perform a search to locate fatal injuries that occurred during wildland fire operations in CFOI. Because wildland fire fighting is combined with structural fire fighting and cannot be identified by its own specific industry or occupation code, multiple variables were used (occupation, industry, event, and activity) to identify wildland firefighters. Two different occupation code schemes were initially used to identify cases. For 2001–2002, the following BOC codes were selected: 079 (foresters and conservationists); 226 (airline pilots and navigators); 243 (supervisors-forestry); 413 (supervisors, firefighting, fire prevention); 417 (firefighting operations); 494 (supervisors-forestry and logging workers); and 495 (forestry workers, except logging). For data from 2003–2011, the following SOC codes were selected: 33–2022 (forest fire inspectors and prevention specialists); 33–1021 (first-line supervisors/managers of firefighting and prevention workers); 33–2011 (firefighters); 33–2021 (fire inspectors and investigators); 53–2012 (commercial pilots) and 53–2011(airline pilots, copilots and flight engineers). Similarly, two different industry code schemes were used to identify additional cases. For 2001–2002, the following SIC codes were selected: 9224 (fire protection) and 0851 (forestry services). For data from 2003–2011, the following NAICS codes were selected: 115310 (support activities for forestry) and 922160 (fire protection). The OIICS event codes for "forest, brush, or other outdoor fire" ("5130" (2001–2010 data); "3160" (2011 data) were used to identify additional cases not identified by occupation and industry codes. Last, to supplement the search, a keyword search of the incident narratives was used to identify additional cases that were related to wildland fire but may not be coded to the aforementioned occupation, industry, and OIICS codes. For this final search, keywords included: *brush, burn, bush, control, dozer, engine, fire, fire break, firebreak, fire fighter, firefighter, fire man, fireman, forest, grass, inmate, interface, lightning, prescribe, tanker, timber, volunteer, wilderness, woods, wild fire, wildfire*. All fatalities identified through the code and keyword search were reviewed to ensure the worker was a firefighter and the fatality was associated with wildland fire-related activities. Records were excluded if there was no association or questionable association with wildland fire fighting activities or employment as a wildland firefighter (e.g., farmers). All in-scope cases were input into a separate MS Access database.

NIOSH FFFIPP surveillance system

A case-based system of firefighter fatalities, including WFF fatalities, is collected and maintained through the NIOSH Firefighter Fatality Investigation and Prevention Program (FFFIPP). Through the FFFIPP, selected on-duty firefighter deaths are thoroughly investigated and comprehensive recommendations are developed to prevent similar incidents from occurring in the future.[43] NIOSH uses a decision flow chart to prioritize investigations for both traumatic and cardiovascular/medical events (http://www.cdc.gov/niosh/fire/pdfs/FFFIP_DecisionChart.pdf). For traumatic fatalities, priority is given to incidents resulting in multiple fatalities, emerging issues, and incidents involving motor vehicles. For cardiovascular/medical events, priority is given to incidents involving heat-related illnesses, cardiac events during training or on the fire ground, and seizures, overdoses, and diabetes.[44] Although priority is given to on-duty structural firefighter activities, occasionally NIOSH will investigate an on-duty wildland fire-related fatality.

NIOSH tracks all FFFIPP investigation reports in a standardized database and posts the reports on the FFFIPP website. Separate databases are maintained for traumatic and cardiovascular fatalities. To identify wildland-fire related incidents, all reports since 2001 were reviewed. Incidents specifically related to wildland, grass, brush, or outdoor fire during suppression and training were extracted. The NIOSH database administrators confirmed these incidents as wildland fire-related. Each report provides detailed information about the events that occurred before, during, and after the incident, medical/autopsy findings, and information about the decedent's employer and his or her training and experiences.

Data matching and comparison

To describe similarities and differences between the systems, individual fatalities from NFPA, USFA, and NWCG were matched and entered into a MS Access 2010 database. If available, demographic, cause, employment, and geographic variables were included. Cases were matched on incident date and location; fire name and/or forest/state in which the incident occurred; employing agency information; demographics; and cause of death. When a match could not be verified, descriptive incident information was reviewed for confirmation. The FFFIPP cases were not matched to the other three systems as the FFFIPP system was not designed to be a census; thus, it was not practical to compare case characteristics from the FFFIPP system with the population-based systems for this publication. Due to confidentiality and data use restrictions, CFOI data were also not included in the matching process. Through this matching process, coding differences were rectified by reviewing additional sources (e.g., obituaries, newspaper articles, National Fallen Firefighters Memorial website). For some, the decedent's fire department or ranger station was contacted to validate information.

For the overall data summaries, fatalities from USFA, NFPA, CFOI, and FFFIPP were recoded based on the NWCG "type of incident" variable to ensure consistency. Even though the NFPA, USFA, and CFOI systems use categorical cause and nature code schemes more aligned with standard fatality classifications, the NWCG does not provide information describing each fatal event; as a result, it was not feasible to recode NWCG data to match the other systems. For consistency across systems, fatalities were also recorded and analyzed based on year of death, even if the death was delayed considerably after the incident.

Results

Surveillance system characteristics

Table 1 provides a comprehensive comparison of the systems. The largest differences between systems were due to: (1) the inclusion of only line-of-duty deaths (LODDs) (NWCG), verses all on-duty deaths (USFA and NFPA); and (2) whether deaths that occurred after the event were included (e.g., due to the Hometown Heroes Survivors' Benefits Act) (USFA).[45]

For most fatalities, the NWCG only tracked LODDs. This included death occurring while the workers were engaging in specific on-the-job wildland fire response and training activities including deaths that occur while mobilized to a wildland-fire or prescribed burn, during some wildland-fire specific trainings, and during other events. NWCG did not include fatalities that occurred while the worker was participating in other non-emergency on-duty activities such as training activities, aside from work-capacity testing.

The NFPA and USFA, however, captures on-duty fatalities, including most LODDs, as well as worker fatalities that occurred during other assigned non-emergency duties (e.g., non-wildland fire training, vehicle maintenance, or on standby). Based on the descriptive fields and NFPA's emergency/non-emergency classification data, at least 15 fatalities included in either the NFPA or USFA systems but not in NWCG occurred while the firefighter was performing other non-emergency, on-duty work tasks.

Another difference was that after December 15, 2003, the USFA—as part of the Hometown Heroes Survivors' Benefit Act—began including medically-related wildland

fire fatalities (e.g., heart attacks and strokes) that occurred within 24-hours of a non-routine, physically stressful or strenuous emergency response activity.[45] Ten of the wildland fire-related deaths were identified by USFA as "Hometown Heroes." Review of these cases suggested that the 10 cases were exclusively male, mostly volunteer (n = 7) and had an average age at the time of the event of 48 years (range 28–66). Neither the NFPA nor the NWCG case definition included these types of fatalities in their systems; however, NFPA included three of these deaths and NWCG included five. Additional medically related events were included in the USFA system but not in the other two sources. The descriptive field indicated that the deaths likely met the Hometown Heroes criteria; however, because the deaths were not specifically coded as Hometown Heroes by USFA, it could not be concluded that they were identified as a result of the Act.

Another difference was that both NFPA and USFA typically included fatalities that occurred while firefighters, most often volunteers, were traveling to a wildland fire in personal vehicles or fighting a wildfire on their own land (e.g., a firefighter started a fire and attempted to suppress it). The NWCG, however, typically included only fatalities in which the firefighter was officially mobilized from their station and/or was mobilized in an official fire vehicle. In addition, the NWCG included fatalities that occurred among non-fire-related personnel (e.g., law enforcement, non-fire contractors) performing wildland fire-related activities at the time of the incident, but the USFA and NFPA only included personnel whose job duties were specifically fire-related or were classified as "wildland firefighters."

Incident characteristics

NFPA, USFA, and NWCG

The number of wildland fire-related fatalities between 2001 and 2012 differed among the three population-based systems (Table 2). The systems typically differed by a count of one or two fatalities each year, with 12-year totals ranging from 207–223 (average = 17.3–18.6 fatalities/year). The largest difference was noted in 2005, when USFA reported 19 fatalities, NFPA reported 15, and NWCG reported 12.

The USFA captured the largest number of WFF/wildland fire-related events (n = 223), followed by NWCG (n = 210) and NFPA (n = 207). After matching the data, 247 unique WFF and wildland fire related fatalities were identified within these three systems (Table 2). Almost 75% of the total fatalities (n = 181) were identified in all three systems, 13% (n = 31) were identified in two systems, and 14% (n = 35) were identified by only one system. Fatalities that occurred while on-scene at the wildland fire incident (e.g., burnovers/entrapments, aviation-related incidents, and struck-bys) were captured consistently across systems. Fatalities that may have occurred before or after fighting a fire (e.g., while traveling to/from the fire, while off-duty but still in mobilization status, during training, and medical-related incidents) varied between systems.

Characteristics of wildland firefighter deaths

NFPA, USFA, and NWCG

Fatality distributions by gender, age, type of worker, and type of incident were generally similar across systems. Males consistently accounted for more wildland fire-related fatalities (94%) than females, a larger percentage of workers were over the age of 40 (55–56%), and volunteers (27–33%) accounted for the most fatalities.

After recoding the USFA and NFPA data to match the NWCG incident classification, the leading incident type across all three systems were: aviation-related (28–30%); vehicle-related (27–29%); and medical events (23–27%).

Within each of the systems, the leading incident type among "volunteer" firefighters was medical events (41–48%). Fatalities involving aviation contractors were associated with aviation incidents, while entrapment/burnovers (33–36%) were the leading incident type among federal workers. The leading incident type among state WFFs was medical events (30–33%), and vehicle-related events were the leading incident among ground contractors (60–64%). The leading incident type for career/paid firefighters differed, with medical events (31–33%) accounting for the most deaths in the USFA and NWCG systems and vehicle-related incidents in the NFPA system.

Based on an analysis of the 247 unique deaths without regard to the systems, the only notable difference was that medical events accounted for the most deaths (n = 74, 30%), followed by vehicle-related incidents (n = 66, 27%), and aviation-related incidents (n = 65, 26%). It is also important to note that of the total deaths captured in all systems, 36% (n = 88) occurred during multiple fatality incidents and were associated with aviation (n = 53), vehicles (n = 22), and entrapments (n = 13).

Finally, linear regression analysis indicated that the deaths captured in all three systems did not show a statistically significant trend from 2001–2012.

NIOSH FFFIPP wildland fire investigations

Thirty-three FFFIPP wildland fire fatality investigations were conducted during the 13-year study period; 18 were considered traumatic. Twelve were vehicle-related (including four struck-by vehicles and one

Table 2. Demographic characteristics and distribution of wildland firefighter deaths by surveillance system.

Characteristic	Surveillance Data Source			Case included in all three sources n (%)	Case included in at least one source n (%)
	National Fire Protection Association n (%)	United States Fire Administration n (%)	National Wildfire Coordinating Group n (%)		
Year					
Total	207	223	210	181	247
Gender					
Male	194 (93.7)	209 (93.7)	197 (93.8)	170 (93.9)	232 (93.9)
Female	13 (6.3)	14 (6.3)	13 (6.2)	11 (6.1)	15 (6.1)
Age Range					
<20	12 (5.8)	12 (5.4)	12 (5.7)	10 (5.5)	13 (5.3)
20–29	46 (22.2)	47 (21.1)	43 (20.5)	42 (23.2)	48 (19.4)
30–39	33 (15.9)	37 (16.6)	37 (17.6)	33 (18.2)	40 (16.2)
40–49	46 (22.2)	47 (21.1)	45 (21.4)	37 (20.4)	56 (22.7)
50–59	43 (20.8)	46 (20.6)	43 (20.5)	35 (19.3)	52 (21.1)
≥60	27 (13)	34 (15.2)	27 (12.9)	24 (13.3)	35 (14.2)
Unknown[a]	—	—	3 (1.4)	—	3 (1.2)
Employment Type					
Volunteer	56 (27.1)	73 (32.7)	59 (28.1)	48 (26.5)	77 (31.2)
Federal	43 (20.8)	40 (17.9)	41 (19.5)	39 (21.5)	44 (17.8)
Contractor-Aviation	32 (15.5)	35 (15.7)	32 (15.2)	31 (17.1)	36 (14.6)
State	32 (15.5)	27 (12.1)	26 (12.4)	24 (13.3)	32 (13)
Contractor-Ground	24 (11.6)	22 (9.9)	25 (11.9)	22 (12.2)	25 (10.1)
Career	11 (5.3)	16 (7.2)	15 (7.1)	9 (5)	19 (7.7)
Inmate	4 (1.9)	4 (1.8)	4 (1.9)	3 (1.7)	5 (2)
Military	4 (1.9)	4 (1.8)	4 (1.9)	4 (2.2)	4 (1.6)
Other	1 (0.5)	2 (0.9)	4 (1.9)	1 (0.6)	5 (2)
Type of Incident					
Aviation-related incident[a]	61 (29.5)	63 (28.3)	60 (28.6)	58 (32)	65 (26.3)
Medical	47 (22.7)	61 (27.4)	54 (25.7)	37 (20.4)	74 (30)
Medical Non-Heart Attack	6 (2.9)	7 (3.1)	7 (3.3)	5 (2.8)	10 (4)
Medical Heart Attack	41 (19.8)	54 (24.2)	47 (22.4)	32 (17.7)	64 (25.9)
Vehicle (other than aircraft)	59 (28.5)	59 (26.5)	56 (26.7)	48 (26.5)	66 (26.7)
Entrapment/Burnover[b]	24 (11.6)	24 (10.8)	24 (11.4)	24 (13.3)	24 (9.7)
Struck-by	12 (5.8)	12 (5.4)	12 (5.7)	11 (6.1)	13 (5.3)
Electrocution/lightning	2 (1)	2 (0.9)	2 (1)	2 (1.1)	2 (0.8)
Other	2 (1)	2 (0.9)	2 (1)	1 (0.6)	3 (1.2)

[a] Includes smoke jumping and helitack incidents, helicopter-delivered fire resources, where aircraft were involved. [b] A situation where firefighting personnel are unexpectedly caught in a fire behavior-related, life-threatening position.

all-terrain vehicle-related incident), five were entrapments/burnovers, and one was struck-by object other than a vehicle. The remaining 15 fatalities were cardiovascular incidents, with all but two due to cardiac events (i.e., heart attacks). Most of the FFFIPP cases were volunteer firefighters (n = 20) followed by career/paid firefighters (n = 8). Males accounted for all but two of the fatalities and the average age of the decedent was 41 years (range 16–66).

BLS CFOI

Based on the review of CFOI, there were 140 WFF fatalities from 2001–2012, resulting in an annual average of 11.7 deaths. Fifty-three were private employees (e.g., contractors), 37 were federal employees, 34 were local government employees (including volunteers and inmates), and 20 were state employees. Aviation (n = 54) and vehicle-related incidents (n = 46) accounted for a majority of these fatalities, followed by entrapments/burnovers (n = 23) and struck-by object incidents (n = 10). Medical events, specifically heart attacks and strokes are typically not included in CFOI as these events are considered illnesses and therefore excluded from CFOI unless a traumatic injury contributed to the death. Males accounted for most of the fatalities (n = 132) and workers over the age of 35 accounted for over half (52%) of the deaths.

Discussion

This study complements the 2011 paper by Estes et al.[29] by specifically describing datasets that include fatalities among a subset of firefighters who suppress fires in

non-structural settings. Similar to findings by Estes et al., the four population-based systems (e.g., NFPA, USFA, NWCG, and CFOI) indicated volunteers made up the largest proportion of WFFs killed on-duty or in the line-of-duty. In contrast to the findings from Estes et al., aviation-related incidents were the leading cause of death for WFFs in all four systems, which is likely due to firefighters reliance on aircraft during fire suppression activities. These aviation related deaths are further characterized using a multi-surveillance system approach in a recent study.[46] A similar approach could also be utilized to explore "volunteer" fatalities, specifically looking at factors and conditions that place them at a higher risk for medical-related events. In addition, while the FFFIPP is not a census, the multifactorial fatality investigation reports produced by this program provide detailed event, training, medical, and personnel records that could be used in future research to identify risk factors for wildland firefighter fatalities.

Our sentinel research represents the first study using multiple surveillance systems to match and compare all WFF fatalities in the U.S. The findings are important because differences in the types of incidents within each system are identified. Differences can often be attributed to case definitions and the intended use of the data. For example, NWCG designed their system to track only fatalities that occurred during specific activities, most often at a wildfire, prescribed fire, or during work-capacity testing. As a result, the NWCG data are not representative of all WFF fatalities; rather, they represent fatalities that occur only during select activities mostly associated with fire suppression. Unlike the USFA and NFPA systems, the NWCG does not track fatalities that occur while WFFs are performing other assigned non-fire job duties, even if the worker is, for example, being paid and on-call. Furthermore, aside from basic statistics, the NWCG data cannot be used to perform detailed analyses of fatalities without supplemental information from other sources. Based on published NWCG data and reports,[47,48] the NWCG often uses the data to track and report broad statistics and trends.

Conversely, the NFPA and USFA collect information for all fatalities occurring during wildland fires and wildland fire-related activities, including all on-duty deaths. These systems can provide a more comprehensive understanding of the risks firefighters face while "on-duty." The inclusion of all deaths is important; research specific to structural firefighters has suggested that firefighters spend less than 5% of their time engaged in actual fire suppression activities; the remainder of their time is spent doing other work tasks.[49] Although this estimate is specific to structural fire work, and there are no published estimates of the amount of time WFFs are engaged in wildfire suppression, it is generally recognized WFFs do not spend all of their time engaged in fire suppression activities. It is important to understand the risks associated with all work tasks, not just fire suppression. Systems, such as NWCG, that capture only LODDs are useful for understanding fatalities that occur during fire suppression and other select activities, however, the true burden on this population can be mischaracterized.

The BLS CFOI system identified fewer fatal occupational injuries than the other population-based systems. Although CFOI data could not be matched to the other data sources, we suspect a portion of the difference may be due to the fact that CFOI primarily captures traumatic injuries and excludes most medical events (e.g., heart attacks and strokes) unless a traumatic injury contributed to the medical related death.[41] While the exclusion of medical events from CFOI may impact the capture of wildland fire-related deaths, we agree with Estes et al.[29] and believe CFOI can be used to compare WFF with fatalities occurring among workers in other occupations since CFOI is a census of all work-related fatal injuries in the US.

Other differences in case criteria (e.g., inclusion of fatalities from the Hometown Heroes Survivors' Benefits Act, or fatalities that occur while a worker is en route to a fire in a personal vehicle) can lead to confusion and mischaracterization of data due to differences in the number of captured fatalities. Without conducting a thorough analysis and having an in-depth understanding of the criteria for each system, it is easy to inaccurately interpret the data. For these reasons, it would be beneficial for the various agencies to (a) adopt a common case classification system or (b) provide more detailed information about inclusion criteria when reporting fatalities.

To ensure consistency and facilitate future analysis of WFF fatality data, NIOSH researchers offer a case definition of a WFF fatality that is most consistent with the definition used by the USFA.

> *Any fatal injury or illness (e.g., sudden cardiac or cerebrovascular event) sustained among WFFs while on-duty at a wildland fire-related event or while performing wildland fire duties in the U.S.*
>
> *"Wildland fire" refers to a non-structure fire occurring in vegetation or natural fuels and includes prescribed fire and wildfire.*
>
> *"Wildland firefighter" refers to a person whose principal function is fire suppression (includes paid/career and volunteer workers)*
>
> *"On-duty" refers to*:
>
> - *a wildland fire or non-fire activity;*
> - *responding to or returning from a wildland fire;*

- *performing other officially assigned wildland fire or wildland firefighter duties, such as reconnaissance, physical fitness training, maintenance, public education, or investigations;*
- *being on call, under orders, or on standby duty, except at the individual's home or other place of business; and*
- *events covered under the Hometown Heroes Survivors' Benefits Act of 2003.*

Fatalities that would be excluded would be those involving non-fire personnel (e.g., law enforcement officers), those occurring in U.S. territories and overseas military installations, commutes to/from work, and recreational activities not required by the department/agency.

Determining the work-relatedness of most fatal traumatic injuries is typically straightforward, however, difficulties arise in determining the origin, cause, and work-relatedness of some on-duty fatal conditions such as on-duty cardiovascular disease related events.[50] Research specific to structural firefighters has indicated an increased risk of cardiovascular disease-related fatalities during activities such as fire suppression and physical training.[49,51] While structural and wildland fire environments and suppression tactics are different, certain occupational factors shown to increase cardiovascular risk among structural firefighters (e.g., smoke and particulate exposure, physical exertion, fire response, and psychological stressors) are also present among wildland firefighters.[49,51–57] In addition, presumptive laws for firefighters in 37 states have enacted various forms of "presumptive disability" laws, which suggest that "heart diseases" and other illnesses are job related for purposes of workers' compensation, disability retirement, medical expenses, and lost wages, unless proven otherwise.[58] For these reasons, on-duty medical events including fatal cardiovascular events should continue to be included in wildland fire-related fatality tracking systems.

Limitations

This study was subject to at least six limitations. The NWCG surveillance system does not contain identifying information; therefore, information from other systems used to update the NWCG data may have introduced some demographic misclassifications. However, due to the limited number of fatalities and the detail used to match the records (e.g., date, region, type of fatality, employing agency), this misclassification was likely minimized.

Second, workers who had performed both wildland and structural fire duties during the work shift prior to their death were likely coded differently between systems. Some of these deaths, especially fatalities that are covered under the Hometown Heroes Survivors' Benefit Act and fatalities involving vehicles (e.g., where the firefighter was dispatched from a wildland fire to a structural fire or vice versa), were classified differently within each system. Without access to all firefighter fatality data in all systems, it is not feasible to identify and consider all inconsistencies.

A third limitation, inherent for most surveillance systems and noted in the findings of Estes et al.,[29] was that it was not feasible to assess the impact, if any, that these systems may have had on wildland fire-related deaths. However, organizations like the NWCG have implemented policies and work-practices based on system findings.

The fourth limitation was the lack of accurate denominator data. Because the total number of workers who engage in wildland-fire related activities is generally unknown, it was not possible to calculate accurate rates. Therefore, this article could only offer findings based on the raw distribution of cases.

The fifth limitation was related to CFOI. Because wildland firefighters are combined with similar occupations and industries, and because the narrative field may not provide information on the specific type of fire, it is likely that some in-scope cases may have been excluded because an association between the fatality and a *wildland fire* could not be made. This was primarily an issue for motor vehicle-related incidents as it was not possible to determine the type of fire, and for aircraft incidents as it was not possible to determine the type of forestry work the pilot was performing. It is also possible that wildland firefighters performing other official non-fire related duties were coded as forestry workers. In these instances, if the narrative and activity fields did not indicate wildland fire activities, these cases were excluded.

Last, all of these systems, except CFOI, capture both medical and traumatic fatalities. However, there are limited mechanisms for identifying fatalities associated with chronic illnesses (e.g., cancer, respiratory disease) attributed to occupational exposures, especially if these illnesses occur off-duty or after separation from the fire service. Thus, it was not feasible to include these types of chronic illnesses in this study.

Conclusions

While each system reviewed is unique and had varying case criteria for capturing wildland fire fatalities, the goal of each system is to collect accurate and timely information, improve safety, and use the results to guide the development of viable prevention strategies. Use of a common case definition would help to more accurately characterize WFF deaths, lessen the likelihood for the misinterpretation of WFF data, and assist with defining

the true occupational fatality burden. By using this definition, researchers and fire managers could gain a better understanding of WFF fatalities in their efforts to develop effective prevention strategies uniquely oriented to WFFs.

Subsets of this specialized workforce disproportionally experience certain fatality types. Additional research is needed to more fully describe deaths among volunteer firefighters. This population is typically not covered by OSHA (Herb Gibson, Occupational Safety and Health Administration, May 2011) and, as FFFIPP investigations have suggested, the level of awareness and compliance with fire standards and policies vary among departments.[59–61] Next steps will be to further analyze all wildland fire-related fatality data in more detail and to identify research needs related to wildland fire-related fatalities among volunteer firefighters.

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Disclaimer

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the United States Forest Service.

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