Annals of Epidemiology 23 (2013) 37–42

Contents lists available at SciVerse ScienceDirect

Annals of Epidemiology

journal homepage: www.annalsofepidemiology.org

Fire characteristics associated with firefighter injury on large federal wildland fires

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ARTICLE INFO

Article history:
Received 10 September 2012
Accepted 9 November 2012
Available online 2 December 2012

Keywords:
Occupational safety
First responders
Ecologic study

ABSTRACT

Purpose: Wildland fires present many injury hazards to firefighters. We estimate injury rates and identify fire-related factors associated with injury.
Methods: Data from the National Interagency Fire Center from 2003 to 2007 provided the number of injuries in which the firefighter could not return to his or her job assignment, person-days worked, and fire characteristics (year, region, season, cause, fuel type, resistance to control, and structures destroyed). We assessed fire-level risk factors of having at least one reported injury using logistic regression. Negative binomial regression was used to examine incidence rate ratios associated with fire-level risk factors.
Results: Of 867 fires, 9.5% required the most complex management and 24.7% required the next-highest level of management. Fires most often occurred in the western United States (82.8%), during the summer (69.6%), caused by lightening (54.9%). Timber was the most frequent fuel source (40.2%). Peak incident management level, person-days of exposure, and the fire's resistance to control were significantly related to the odds of a fire having at least one reported injury. However, the most complex fires had a lower injury incidence rate than less complex fires.
Conclusions: Although fire complexity and the number of firefighters were associated with the risk for at least one reported injury, the more experienced and specialized firefighting teams had lower injury incidence.
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Introduction

Wildfires across the United States cost governments, insurers, and private individuals billions of dollars per year and burn millions of acres. Changes in fire suppression tactics, climate change, and increasing incursion of housing into rural and wilderness areas have caused fires to burn more intensely, grow larger, and threaten more residential areas escalating costs and increasing risks to firefighters.

Each year in the United States approximately 100 firefighters die in the line of duty [1]. From 1997 through 2007, excluding 2001, about 17% of the deaths occurred during wildland firefighting activities [2]. During the same period, the National Fire Protection Association [3] estimated that 370,000 injuries occurred to firefighters on the scene at fires. If the proportion of overall firefighter to wildland firefighter injuries is similar to fatalities, we estimate that 60,000 of these injuries occurred during wildland firefighting activities. Despite the potential for a significant number of injuries, we know little about them.

Most research to date regarding occupational hazards to wildland firefighters assesses exposures to smoke or other related toxics or examines physiological responses to firefighting activities [4–14]. Information about the injuries in firefighters is derived from summary reports and limited research describing the distribution of injuries at wildfire events [15,16]. No previous literature evaluating personal or fire-level risk for injuries on wildfires was identified. One study examined incident-level risk for injury on structure fires [17]. Structure fires, however, use different equipments and techniques than used on most wildland fires.

To address this critical information gap, we used epidemiologic methods to expand on previous descriptive studies. We estimated rates of injury and evaluated fire-level risk factors for rate of injury and injury occurrence on large wildfires burning in federal jurisdiction that were reported to the National Interagency Coordination Center in the years 2003–2007. We hypothesized that fire-level characteristics are predictive of both injury occurrence and rate of injury.

Methods

Data sources

The unit of analysis for this ecologic study was wildland fires (rather than individual firefighters). Data were obtained from the

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http://dx.doi.org/10.1016/j.annepidem.2012.11.001

Incident Management Situation Report (IMSR) system maintained by the National Interagency Coordination Center in Boise, Idaho, which collects information on large fires that require federal response. This information is publicly available for download via the National Fire and Aviation Management Web site (http://fam.nwcg.gov/fam-web/, accessed 31.12.08). Incidents coded as "wildfires" from January 1, 2003 through December 31, 2007 were included.

Federal fire management agencies are required to report fires to IMSR. The federal wildland fire management agencies that fall under reporting requirements are the U.S. Forest Service and the following agencies within the Department of the Interior: Bureau of Land Management; Bureau of Indian Affairs; Fish and Wildlife Service; and National Park Service. Nonfederal entities such as states may voluntarily report through this system but were excluded from this analysis because reporting is not mandated. A final report for each fire includes cumulative information about injuries, personnel deployed, and fire characteristics.

Fires that met inclusion criteria but were missing the total number of injuries, information about the number of personnel assigned to the fire, or both were excluded. Fires were also excluded if the number of personnel assigned was reported to be zero (Fig. 1).

Main outcome variables

Injuries were defined as those in which the firefighter was unable to return to his or her fire assignment for a period long enough to require redeployment of firefighters. The exact period that the firefighter was not able to return to the fire assignment was not specified in the reports. Two outcome variables were examined. The first outcome was a dichotomous measure of whether any injuries were reported on each fire. The second outcome was the rate of injury per fire, calculated by dividing the number of injuries by the number of person-days accumulated by deployed personnel over the course of the fire. The number of person-days for each fire was estimated by adding the total number of personnel reported on each summary report for each day of the fire.

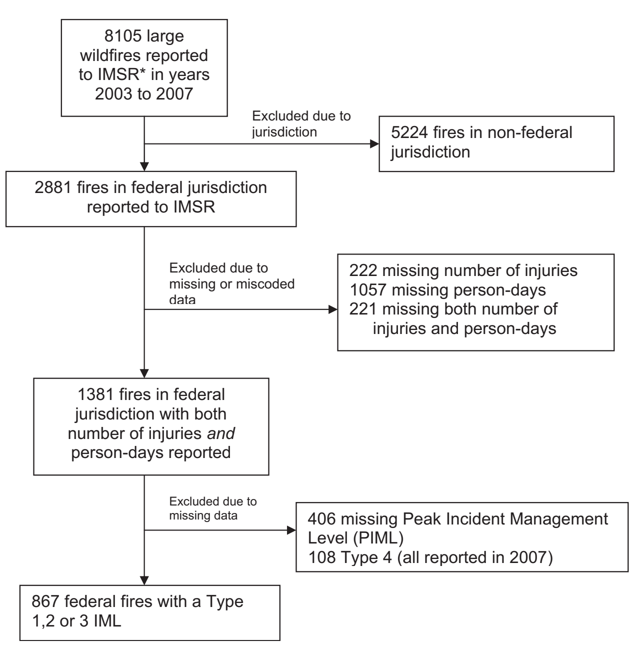

Fig. 1. Data flowchart for inclusion in analysis sample. *IMSR, Incident Management Situation Report system of the National Interagency Coordination Center.

Main exposure

The main exposure variable was the highest level of firefighting management intensity required during the fire, called peak incident management level (PIML). The PIML is assigned to one of the four levels based on the complexity of the fire as determined by staff of the agency having jurisdiction over the fire. Factors involved in determining incident complexity include threats to life or property, current and predicted weather, environmental influences like topography and fuels, and availability of resources and safety of both firefighters and the surrounding communities. Type I fires are the most complex and require elite firefighting units, often from multiple agencies; type IV fires are the least complex and often involve only a local firefighting unit. Only fires assigned incident management levels I–III are routinely reported and thus are the only levels included in this analysis. The incident management level can be changed throughout the duration of a fire, and this analysis considered the highest level assigned to each fire.

Confounding variables

Several confounding variables were examined. Season of fire occurrence was defined as either peak season (summer months of June, July, and August) or off-season (months of September through May). Fire regions included the western and eastern United States. Based on similar fire types, the western region included the Rocky Mountain states west as well as South Dakota, North Dakota, Nebraska, and Kansas; all other states were coded with the eastern region.

Fire cause was categorized as human, natural (such as lightning), or under investigation. Fuel was categorized according to the vegetation that fed the fire and included three basic types: grass and grass dominated; chaparral and shrub fields; as well as timber and slash [18,19]. "Fire resistance to control" describes three primary factors that influence fire spread: fuel type and fuel moisture; topography of the area in which the fire was burning; and air mass. Topography included both the slope and the elevation of the area. Air mass took into account such factors as the temperature, relative humidity, wind speed and direction, and precipitation and also may include forecasted weather events. Resistance to control was rated on a four-point scale from low to extremely resistant. Peak resistance to control, the most extreme value reported at any time during the fire, was chosen for this analysis. Destruction of structures was defined as whether any structures were reported lost at any time during the fire.

Analysis

Mean rates of injury per 10,000 person-days of exposure were calculated for each fire and summarized for the main exposure and confounding variables. Because of violations of assumptions of normality, a nonparametric Kruskal–Wallis test was used to compare the medians of injury rates across categories. Multiple Wilcoxon rank sum comparisons were used, and multiple comparisons were considered significant at $P \leq .01$.

Logistic regression was used to assess the association of fire-level risk factors and the dichotomous variable of no injury versus one or more injuries occurring on a fire. The model included PIML as the main exposure variable and all identified confounders. Person-days were controlled in the logistic model by creating quartiles of reported total person-days. A Hosmer and Lemeshow goodness-of-fit test was conducted to assess model fit [20,21].

Negative binomial regression was used to test the association of PIML, the main effect variable, and potential confounders on the rate of injury [22–24]. A negative binomial model was chosen over a Poisson model based on the overdispersion in the data. Likelihood ratio testing of whether the dispersion parameter was zero was used to assess model fit. A zero-inflated negative binomial model was considered based on the excessive zeros within the data; however, the Vuong test [25] results comparing the zero-inflated model with the negative binomial model suggested that there was no explanatory improvement in the zero-inflated negative binomial model over the standard negative binomial model given the available variables. All statistical analysis used SAS v 9.1 (SAS Institute, Inc., Cary, NC) and Stata 10 (StataCorp, LP, College Station, TX). Statistical significance was set at alpha less than or equal to 0.05.

Results

From January 1, 2003 through December 31, 2007, 8105 wildfires were reported through the IMSR system. Of these fires, 2881 (35.5%) occurred on lands in federal jurisdiction, and of these, 1381 (47.9%) had complete information for total injuries and total person-days. Only the 867 (30%) fires that reported a type I (most complex), II, or III PIML were included (Fig. 1).

In this sample, the most fires were reported in 2006 (29%) with the fewest in 2004 (15%). Seventy percent occurred during the peak season, and more than 80% occurred in the western United States. Lightning was the cause of ignition for more than half the fires. Timber was the most common fuel type at almost 40%, followed closely by the grass and shrub types. Thirty-five percent of fires were rated as having high resistance to control, and 30% of fires were described as having low resistance to control. Only 15% of the fires reported destruction of any structures.

The most complex fires, those assigned a PIML type I, were proportionately the greatest in 2007, whereas less complex type II and III fires were proportionately greatest in 2006 (Table 1). The western region accounted for more than 90% of all type I and II fires but only 75% of type III fires. Although most fires reporting a PIML of type I, II, or III occurred during the peak season, a larger proportion of type III fires occurred during the off-season. Lightning was the most common cause regardless of PIML. Timber was the most common fuel type for type I and II fires and grass the most common for type III. Almost 50% of type I fires reported extreme resistance to control, compared with only 6% of type III fires. About 50% of type II fires reported high resistance to control. Destruction of structures was proportionately most likely to be reported among type I fires and least likely for type III fires.

The overall mean injury rate for wildland firefighters was 13.2 per 10,000 person-days (SD = 48.62) (Table 2). Injury rates increased as the complexity of the fire decreased: type I fires had a mean injury rate of 3.6 (SD = 5.35); type II fires had an injury rate of 11.7 (SD = 30.1); and type III fires had an injury rate of 15.2 (SD, 56.9) per 10,000 person-days ($P < .001$). Pairwise comparisons demonstrated differences between all levels ($P < .01$). The lowest reported mean injury rate of 2.3 injuries (SD, 3.9) per 10,000 person-days was found for type I fires in the year 2006. The highest observed mean injury rate of 32.0 injuries (SD, 55.7) per 10,000 person-days was found for type II fires categorized as having low resistance to control.

Table 3 summarizes the logistic regression model assessing the outcome of any reported injury versus no reported injury. After adjusting for person-days of exposure, season, and fire characteristics, the odds of any injury versus no injury was 1.6 (95% confidence interval [CI], 0.7–2.8) for type I fires and 1.9 (95% CI, 1.4–3.2) for type II fires, with type III fires serving as the reference. As the number of person-days increased, the odds of having a reported injury increased. Fires that were in the highest quartile of person-days (>1647) were 22 times more likely to have at least one reported injury (95% CI, 8.8–55.1). Fires that were extremely resistant to control had a 2.1 increased odds for injury compared with low-resistance fires (95% CI, 1.1–4.2). Season, region, cause, and damage to structures were not predictive of the odds of having at least one reported injury. Hosmer and Lemeshow goodness-of-fit tests indicated a good fit ($\chi^2 = 4.75$, $P = .78$).

Table 4 summarizes the negative binomial regression model assessing the outcome of injury rate per 10,000 person days. Compared with type III fires, the adjusted incident rate ratio for type I fires was 0.36 (95% CI, 0.25–0.53) and for type II fires was 0.74 (95% CI, 0.56–0.99). Fire type was the only risk factor significantly predictive of rate of injury.

Table 1
Selected characteristics of wildfires in federal jurisdiction reported to the U.S IMSR system from 2003 to 2007

Total	PIML			Total
	Type I (most complex)	Type II (moderately complex)	Type III (least complex)	
	$N = 82$	$N = 214$	$N = 571$	$N = 867$
Fire characteristic	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Person-days				
<71	1 (1.2)	2 (0.93)	217 (38.0)	220 (25.4)
>71 and ≤309	2 (2.4)	7 (3.3)	205 (35.9)	214 (24.7)
>309 and ≤1647	12 (14.6)	66 (30.8)	139 (24.3)	217 (25.0)
>1647	67 (81.7)	139 (65.0)	10 (1.8)	216 (24.9)
Year				
2003	14 (17.1)	49 (22.9)	106 (18.6)	169 (19.5)
2004	12 (14.6)	21 (9.8)	97 (17.0)	130 (15.0)
2005	7 (8.5)	40 (18.7)	134 (23.5)	181 (20.9)
2006	23 (28.1)	61 (28.5)	167 (29.2)	251 (28.9)
2007	26 (31.7)	43 (20.1)	67 (11.7)	136 (15.7)
Region				
Western	75 (91.5)	209 (97.7)	434 (76.0)	718 (82.8)
Eastern	7 (8.5)	5 (2.3)	137 (24.0)	149 (17.2)
Season				
Peak (June, July, August)	64 (78.1)	178 (83.2)	361 (63.3)	603 (69.6)
Off-season	18 (21.9)	36 (16.8)	209 (36.7)	263 (30.4)
Cause				
Human	16 (19.8)	43 (20.1)	189 (33.1)	248 (28.6)
Lightning	55 (67.9)	144 (67.3)	276 (48.3)	475 (54.9)
Under investigation	10 (12.3)	27 (12.6)	106 (18.6)	143 (16.5)
Fuel type				
Grass	5 (6.7)	51 (27.1)	193 (45.5)	249 (36.2)
Shrub	25 (33.3)	36 (19.2)	101 (23.8)	162 (23.6)
Timber	45 (60.0)	101 (53.7)	130 (30.7)	276 (40.2)
Resistance to control				
Low	0 (0.0)	17 (8.0)	234 (43.6)	251 (30.2)
Moderate	4 (4.9)	33 (15.4)	128 (23.9)	165 (19.8)
High	38 (46.3)	110 (51.4)	144 (26.9)	292 (35.1)
Extreme	40 (48.8)	54 (25.2)	30 (5.6)	124 (14.9)
Structures destroyed				
Yes	32 (39.0)	40 (18.7)	59 (10.3)	131 (15.1)
No	50 (61.0)	174 (81.3)	512 (89.7)	736 (84.9)

Frequency counts do not always sum to total because of missing data.

Discussion

As hypothesized, the PIML of large federal wildland fires was found to be an important factor in firefighter injury. PIML was associated with any reported injury severe enough to preclude the firefighter from returning to his or her job assignment as well as the rate of injury. The two models examined show different aspects of risk for firefighter injury. Compared with the least complex type III fires, the odds of any injury being reported on a fire were significantly greater in type II fires and nonsignificantly elevated in the most complex type I fires. This estimate indicates that fires that

Table 2
Mean rates of injury per 10,000 person-days for large wildfires in federal jurisdiction reported to the U.S. IMSR system from 2003 to 2007

Fire characteristic	PIML			Total
	Type I (most complex)	Type II (moderately complex)	Type III (least complex)	
	Injuries per 10,000 person-days, mean (SD)	Injuries per 10,000 person-days, mean (SD)	Injuries per 10,000 person-days, mean (SD)	Injuries per 10,000 person-days, mean (SD)
Year				
2003	5.84 (7.9)	8.04 (11.7)	10.91 (41.6)	9.66 (33.6)
2004	4.04 (6.7)	4.45 (5.2)	24.00 (84.7)	19.00 (73.6)
2005	3.98 (5.9)	8.07 (8.9)	16.55 (60.3)	14.19 (52.1)
2006	2.28 (3.9)	17.93 (34.3)	13.39 (49.6)	13.48 (44.0)
2007	3.29 (3.8)	13.92 (50.4)	10.59 (32.4)	10.25 (36.3)
Region				
Western	3.48 (5.3)	11.30 (29.4)	15.69 (56.6)	13.14 (46.9)
Eastern	5.06 (6.3)	28.00 (53.8)	13.43 (57.9)	13.52 (56.3)
Season				
Peak (June, July, August)	3.92 (5.7)	11.19 (27.8)	13.50 (43.9)	11.80 (37.3)
Off-season	2.51 (3.7)	14.19 (39.9)	18.06 (74.2)	16.46 (67.8)
Cause				
Human	6.26 (8.1)	6.22 (18.8)	21.26 (74.7)	17.68 (66.0)
Lightning	2.78 (4.2)	14.57 (34.8)	11.36 (46.6)	11.34 (40.5)
Under investigation	4.32 (4.6)	5.09 (5.6)	14.11 (41.7)	11.72 (36.2)
Fuel type				
Grass	3.31 (3.2)	17.02 (34.4)	13.36 (52.5)	13.90 (48.8)
Shrub	3.42 (6.5)	8.69 (14.8)	17.38 (52.1)	13.29 (42.0)
Timber	3.83 (5.2)	11.53 (34.9)	17.10 (60.7)	12.90 (46.9)
Resistance to control				
Low	0 (0.0)	31.99 (55.7)	11.87 (53.1)	13.23 (53.4)
Moderate	3.32 (3.4)	16.64 (57.6)	23.44 (78.1)	21.59 (73.4)
High	4.52 (7.0)	8.51 (14.2)	9.61 (24.6)	8.53 (19.5)
Extreme	2.78 (3.2)	8.77 (10.1)	14.10 (23.8)	8.12 (14.1)
Structures destroyed				
Yes	3.41 (5.2)	11.02 (16.4)	27.67 (92.8)	16.66 (63.6)
No	3.74 (5.5)	11.85 (32.5)	13.70 (51.1)	12.59 (45.5)

Percentages do not always sum to 100% resulting from rounding.

reach a type I or type II status are more likely to have reported injuries, which is probably because of the complex nature of the fire, an increase in the firefighting force needed to fight the fire, and a longer time required to extinguish the fire. The negative binomial model measured the rate of injury per 10,000 person-days and indicated that per person-day, the rate of injury was lower among the more complex type I and II fires. This reduced risk per exposure may be because of the increased coordination and specialty of the firefighters on these more complex fires.

The single factor most predictive of whether any injuries were reported on a fire after controlling for other variables was the number of person-days. Fires in the quartile with the highest number of person-days had 20 times the odds of reported injury relative to fires in the lowest quartile. Compared with less than 2% of type III fires, more than 80% of type I fires and 65% of type II fires were in the highest quartile of person-days required to extinguish the fire. This distribution of firefighting effort is consistent with the previous reports [16,18,26]. In general, type I fires occur later in the season, often burning until snowfall in the Pacific Northwest and northern Rocky Mountain areas [26]. Because these fires can be long and late in the season, fatigue may be a factor. Although previous studies have not examined injury incidence throughout the fire season, overexertion is a commonly cited cause of firefighter injury and supports the role of fatigue as an important risk factor [27,28].

Both fire type and the fire's resistance to control were predictive of any injury after controlling for person-days of exposure. The current reporting format includes these data at the fire level, which do not allow measurement of the effect of these factors on individual injuries. For example, the difficulty of the terrain in which the fire is burning is rated on the same four-point scale as the resistance to control, but more than 90% of fires reported the terrain to be extreme. It may be that specific terrain features, for example, steep or rocky, are predictive of injury occurrence, not a global subjective assessment of terrain difficulty. Previous studies have identified rocky terrain and steep slopes as being risk factors for injury [26,29].

The injury rate for the most complex type I fires, 3.6 per 10,000 person-days, was lower than the rates determined by Keifer and Mangan [16] who found injury rates of 9.1 and 8.3 per 10,000 person-days on the two large fires they evaluated during the 2000 fire season. Keifer and Mangan obtained documents, including the daily summaries, for two of the largest fires of 2000 fire season and collected information on all injuries that were reported from a variety of sources, including the logs from the medical unit. Injuries reported on medical logs included all severities that were treated. In contrast, our study used a more severe definition for injuries, as injuries reported on the summary report include only injuries in which the injured firefighter could not return to his or her fire assignment.

Wildfire is a dynamic process, and one of the significant limitations to this study was our inability to account for transitions in PIML over the course of the fire. As conditions change to either become more complex or less complex, such as when the fire reaches containment or complete suppression, the management responsibility may transition back to a team of lesser experience or management responsibility may be returned to the local agency on whose land the fire occurred [16]. The PIML may represent only a small proportion of a fire's management over the course of the fire.

A second important limitation was our inability to determine when injuries occurred over the course of the fire. The fire reports require that the number of injuries is reported but the actual timing of these injuries is not available on the forms, which are not developed for the purpose of epidemiologic surveillance. The

Table 3
Factors associated with odds of at least one reported injury, controlling for covariates, in large federal wildland fires, United States, 2003–2007

Covariate	Injury, N (%)	No injury, N (%)	Odds of at least one reportable injury during fire, ($N = 831$) Odds ratio* (95% CI)
PIML			
Type I (most complex)	55 (67.1)	27 (32.9)	1.34 (0.65–2.81)
Type II (moderate)	147 (68.7)	67 (31.3)	1.91 (1.40–3.22)
Type III (least)	104 (18.2)	467 (81.8)	1.00
Person-days (quartiles)			
≤71	14 (6.4)	206 (93.6)	1.00
>71 to ≤309	36 (16.8)	178 (83.2)	2.31 (1.11–4.80)
>309 to ≤1647	89 (41.0)	128 (59.0)	6.59 (3.15–13.79)
>1647	167 (77.3)	49 (22.7)	22.02 (8.81–55.05)
Year			
2003	71 (42.0)	98 (58.0)	1.00
2004	37 (28.5)	93 (71.5)	0.87 (0.47–1.63)
2005	54 (29.8)	127 (70.2)	1.05 (0.59–1.85)
2006	83 (33.1)	168 (66.9)	1.01 (0.60–1.70)
2007	61 (44.9)	75 (55.2)	0.88 (0.49–1.58)
Season			
Peak (June, July, August)	249 (41.3)	354 (58.7)	1.00
Off-season	57 (21.7)	206 (78.3)	0.66 (0.39–1.09)
Region			
Eastern	17 (11.4)	132 (88.6)	1.00
Western	289 (40.2)	429 (59.8)	1.21 (0.56–2.62)
Cause			
Human	63 (25.4)	185 (74.6)	1.00
Lightning	192 (40.4)	283 (59.6)	1.03 (0.64–1.67)
Under investigation	51 (35.7)	92 (64.3)	1.38 (0.77–2.45)
Resistance to control			
Low	31 (12.4)	220 (87.6)	1.00
Moderate	55 (33.3)	110 (66.7)	1.64 (0.93–2.91)
High	128 (43.8)	164 (56.2)	1.06 (0.60–1.86)
Extreme	87 (70.2)	37 (29.8)	2.12 (1.06–4.24)
Structures			
No	240 (32.6)	496 (67.4)	1.00
Yes	66 (50.4)	65 (49.6)	1.14 (0.69–1.88)

* Model mutually adjusts for all variables listed in the table.

Table 4
Injury incident rate ratios and association with reported risk factors on large federal wildland fires, United States, 2003–2007

Covariate	Rate of injury during a fire ($N = 831$)	
	Incidence rate ratio per 10,000 person-days*	95% CI
PIML		
Type I (most complex)	0.36	0.25–0.53
Type II (moderate)	0.74	0.56–0.99
Type III (least)	1.00	
Year		
2003	1.00	
2004	1.25	0.845–1.86
2005	1.16	0.80–1.67
2006	1.11	0.79–1.55
2007	0.91	0.64–1.30
Season		
Peak (June, July, August)	1.00	
Off-season	0.86	0.61–1.21
Region		
Eastern	1.00	
Western	0.87	0.49–1.55
Cause		
Human	1.00	
Lightning	1.14	0.83–1.56
Under investigation	1.18	0.80–1.74
Resistance to control		
Low	1.00	
Moderate	0.73	0.47–1.13
High	0.66	0.45–0.98
Extreme	0.66	0.43–1.02
Structures		
No	1.00	
Yes	1.03	0.76–1.40

* Model mutually adjusts for all variables in the table.

reports are primarily used to inform fire managers about the most recent events on the fire to help plan and prioritize resource needs. The injuries to date on the final report provided the best summary of injuries on a fire but provided no individual information about injuries. We were thus unable to evaluate changing levels of injury risk associated with changing fire and management dynamics. Individual-level information, such as the cause and nature of each injury, age, and fitness level of the injured firefighters, was not available. Previous research has indicated that slips, trips, and falls, as well as overexertion are the most common types of injuries to firefighters on structural fires [27].

We were limited in the fire-level characteristics that could be evaluated. Although the terrain and altitude in which firefighters must work may have a significant impact on the injury rate for a particular fire, terrain was described as extreme for almost every fire. The results discussed here are only generalizable to a small percentage of the largest wildfires that occur each year. Most wildfires occur on nonfederal lands, remain small, and are extinguished by local firefighters, many of whom are volunteers also responsible for structural fire.

Despite the limitations, this study shows that the complexity of the fire is related to firefighter injury. Although accrual of increased person-days to fight complicated type I and II fires is an important predictor of whether an injury will occur during a fire, the rate per exposed period is lower on complex fires. This finding suggests that management approaches and fire duty assignments used for complex fires might be translated to less complex fires to reduce injuries. Improved surveillance of injury data throughout the fire would allow assessment of fire characteristics on individual risk for injury over the course of an individual fire and also over the course of a season. Such information could provide a basis for specific injury prevention strategies and for the evaluation of injury prevention efforts.

Acknowledgments

Support for this project was provided by the Centers for Disease Control and Prevention (CDC)/National Center for Injury Prevention and Control-funded University of Iowa Injury Prevention Research Center (CDC R40 CE0011567) and by the CDC/National Institute for Occupational Safety and Health-funded University of Iowa Heartland Center for Occupational Safety and Health.

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