Fire- and Flame-Related Occupational Fatalities in the United States, 1980–1994

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The National Traumatic Occupational Fatalities surveillance system recorded 1518 fire- and flame-related occupational fatalities among the civilian workforce in the United States between 1980 and 1994. The fatalities resulted from 1221 separate incidents, of which 122 involved more than one victim and accounted for 419 of 1518 deaths. Nearly 4 of 10 fatalities resulting from a multiple-victim fire were workers in the manufacturing industry. Similarly, the highest frequency of fatalities in single-victim events, over one fourth, were in manufacturing. For one fourth of the fatalities within each event category, the usual occupation of the deceased was a precision production, craft, and repair worker. Although this study sheds light on selected characteristics of these fatalities, additional research on the causal factors associated with single- and multiple-victim events is needed to present specific recommendations for prevention efforts.

"In these days of more exotic hazards, such as worker exposure to cancer-causing chemicals and crippling ergonomic diseases, such as carpal tunnel syndrome, it is too easy for employers and employees to overlook the equally dangerous hazards of fire." Gerard F. Scannell, then administrator of the Occupational Safety and Health Administration (OSHA), continued by urging "national employer organizations, employee trade unions, and insurance companies to place greater emphasis on fire safety."[1]

According to the United States Fire Administration, every year fires kill more Americans than all natural disasters combined, producing one of the highest fire-death rates per capita in the industrialized world.[2] Nearly 20% of these deaths occur in the workplace. Between 1980 and 1994, fires claimed the lives of over 1500 workers, according to the National Institute for Occupational Safety and Health (NIOSH) National Traumatic Occupational Fatalities (NTOF) surveillance system.

Nationally, the human and economic toll associated with these fire- and flame-related deaths is enormous. In 1997, the National Safety Council estimated that direct property damage from fires exceeded 10 billion dollars, of which nearly one third was attributed to workplace losses. Lost wages and direct expenses accounted for an additional estimated 89 million dollars.[3] These estimates do not include the pain and suffering of the victim prior to death, which can easily be described as agony rather than mere pain. How-

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ever, the human toll does not stop here. Family, friends, and coworkers can experience emotional, physical, and psychological trauma that cannot easily be translated into dollars.

This study uses a national surveillance system covering a 15-year period to examine occupational fire- and flame-related fatalities. The circumstances of each fire are unique, and costs can vary widely for physical damage inflicted and by the number of lives lost in each event. Because of these wide variations, this study examined two categories of fire- and flame-related events. The first category includes single-victim events; the second includes events in which more than one worker was killed. This research presents demographic and employment characteristics of the decedent and identifies circumstances of the fatality for both single- and multiple-victim events. General recommendations for prevention efforts to eliminate large-scale death and destruction were presented for these characteristics. However, developing specific recommendations for multiple-victim events requires additional research.

Methods

Cases in this analysis were taken from the NTOF surveillance system for the years 1980 through 1994. This system has been described previously[4] and consists of all US death certificates in which the "Injury at Work" box was marked "Yes." These records are collected for workers 16 years of age or older for whom an external cause of death was an injury according to the International Classification of Diseases, 9th Revision (ICD-9), codes E800-E999.[5] Although NTOF includes military personnel, data used in this study were for the civilian population only. This census maintained by NIOSH collects death certificates from the vital-statistics–reporting units in the 50 states, New York City, and the District of Columbia on an annual basis.

Limitations of death certificates used to ascertain work-related fatality information have been described elsewhere.[4,6–9] Among the limitations most relevant to this study is a lack of specificity in employment information on the death certificate.[4,6] A further limitation for part of the study period is the absence of national guidelines for completion of the "Injury at Work?" item on the death certificate.[6,7] Operational guidelines for the determination of work injuries were implemented nationwide in 1993. Despite these limitations, death certificates have been shown to identify, on average, 80% of work-related fatalities nationally, more than any other single source.[6,9] The data presented here should be viewed as the minimum number of fire- and flame-related fatalities that occurred during the study period.

For this analysis, cases were selected from NTOF only if the identified external cause of death was "Accidents Caused by Fire and Flames," ICD-9 codes E890-E899. This classification includes asphyxia or poisoning due to conflagration or ignition, burning by fire, and secondary fires resulting from explosions. Fires in private dwellings, buildings, or structures; forest or brush fires; and fires caused by ignition of clothing or highly flammable material, are included in these E-codes, whereas fire in or on operating machinery, fire in or on non-stationary transport vehicles, and arson are excluded.

On the death certificate, industry and occupation are defined as the "usual" industry and occupation of the victim. Industry was grouped into 11 division-level categories as defined by the 1987 Standard Industrial Classification system (Office of Management and Budget).[10] Occupation was categorized into 11 major divisions according to the 1980 and 1990 Bureau of the Census Occupational Classification System.[11] It should be noted that by collecting usual rather than current occupation or industry, certain occupations and industries (such as emergency services and firefighters) identified in this study might be underrepresented.

For this study, a multiple-victim event was defined as a single incident involving two or more fatalities. A multi-step process was used to determine if the incident involved multiple victims. Death certificates from the same state were subset by the victim's date of injury. The event was deemed as a multiple-victim event if these certificates displayed the identical date of injury, hour of incident, and, when identified, firm name or address. The remaining certificates within the initial subset were evaluated on the basis of all available information to ascertain whether the victim was killed in a multiple-victim event.

Average annual employment data used to calculate occupational fatality rates were obtained from *Employment and Earnings*.[12] Employment data from this Bureau of Labor Statistics publication are based on the Current Population Survey, a monthly household survey of the civilian non-institutional population aged 16 years and older conducted by the Bureau of the Census.

Results

Over the 15-year period from 1980 to 1994, 1518 workers lost their lives by "Accidents Caused by Fire and Flames." Of these, well over one half of the victims perished on the same day of injury, whereas nearly two thirds died before the end of the following day. An additional one fourth of the fatalities occurred within 30 days of the incident, whereas 11 victims survived between 4 to 18 months beyond the day of injury.

Nearly one third of these deaths occurred in three of the earlier years of the study—1980, 1984, and 1985. Although the number and rate of deaths per 100,000 workers varied substantially from year to year, overall there was a decline from a high of 160 deaths in 1980 to a low of 46 deaths in 1993 (Fig. 1).

Over 650 of the 1518 fatalities were caused by fires in buildings other than private dwellings, such as churches, schools, stores, and factories. Ignition of highly flammable materials accounted for the second largest number of deaths, just over 200. The only other ICD-9 external cause code that accounted for more than 10% of the total fire- and flame-related fatalities was fires occurring in private dwellings (Fig. 2).

Four states (California, Illinois, Pennsylvania, and Texas) accounted for almost one third of the fire-related deaths during this 15-year period. However, when rates per 100,000 workers were calculated, the highest rates were found in the District of Columbia, Louisiana, Nevada, and Utah. Furthermore, the rates of these three states and the District of Columbia were nearly double the rates of those states that experienced the highest frequencies.

Male workers were far more likely than female workers to be victims of fire- and flame-related occupational fatalities. Male workers accounted for 9 of 10 deaths and experienced a fatality rate eight times higher than the rate for female workers. Although white workers accounted for nearly 80% of these fatalities and black workers accounted for just under 15%, the rate for black workers was 1½ times greater than that for white workers.

The number of deaths peaked in the 25- to 34- year-old age group, then declined with age. Conversely, the risk of fatality tended to increase with age. Less than one tenth of the victims were 65 or over; however, this age group exhibited a fatality rate nearly three times higher than any other age group. The youngest workers—age 19 and under—had the lowest risk as well as the fewest number of fatalities from an incident caused by fire and flames (Fig. 3).

Over one fourth of the victims were employed in the manufacturing industry, with an additional one fourth employed in either the construction or services industries (Fig. 4). The finance, insurance, and real estate industry employed the fewest number of victims and concurrently experienced the lowest fatality rates (Fig. 5). By far the highest fatality rate was sustained by the mining industry—more than three times higher than any other industry division.

One fourth of the victims were reported as working in the precision production, craft, and repair occupations, which includes mechanics, repairers, and construction trade workers (Fig. 6). The highest fatality rate occurred for individuals usually employed as laborers (Fig. 7). Noteworthy is that 5 of the 11 occupational divisions individually show fatality rates that are much higher (nearly 1½ times greater) than any one of the remaining individual divisions.

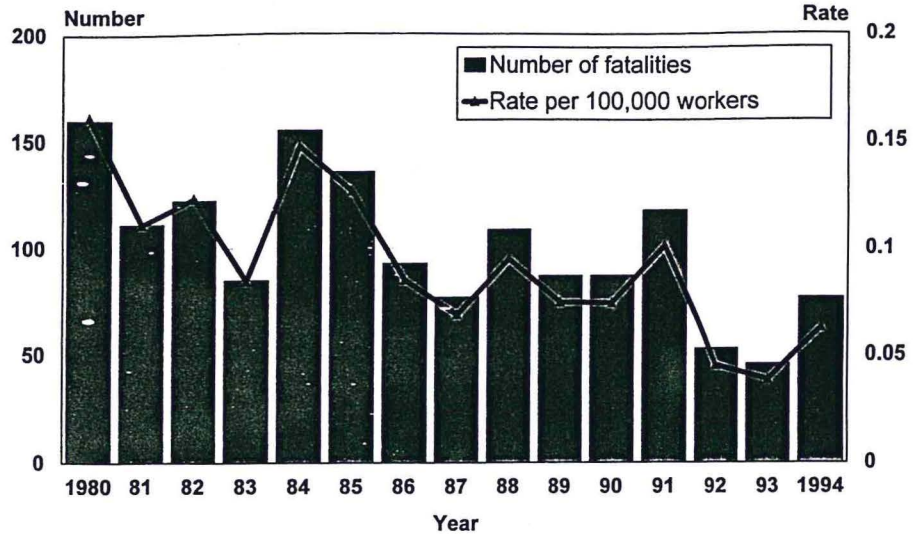

Fig. 1. Number and rate of occupational fatalities due to fire and flames by year, 1980 through 1994.

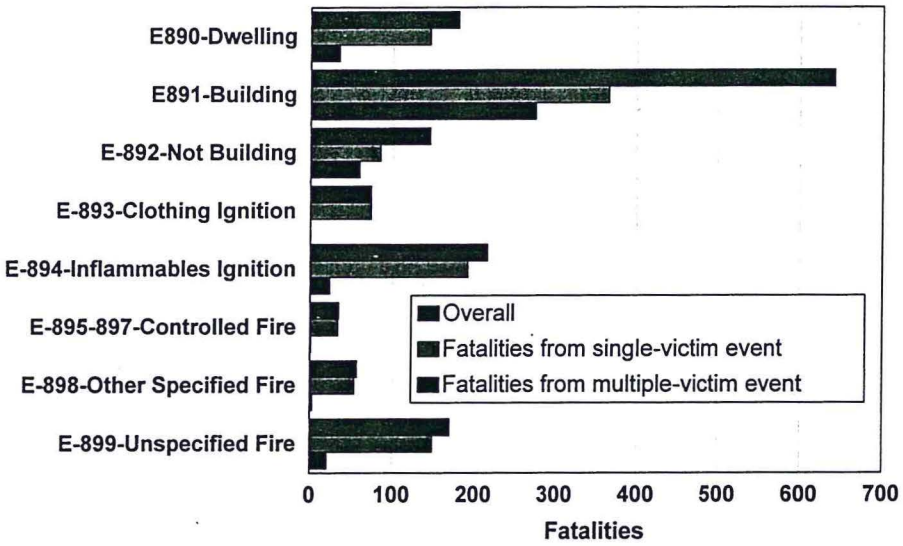

Fig. 2. Number of occupational fatalities for single-and multiple-victim events by cause of death, 1980 through 1994.

Multiple-Victim Incidents

Ten percent of all occupational incidents caused by fire and flames involved two or more fatalities. Of these 122 multiple-victim incidents, just over one of eight took five or more lives and six of those events involved 10 or more fatalities. Over one fourth of the multiple-victim incidents caused by fire and flames occurred in four states—California,

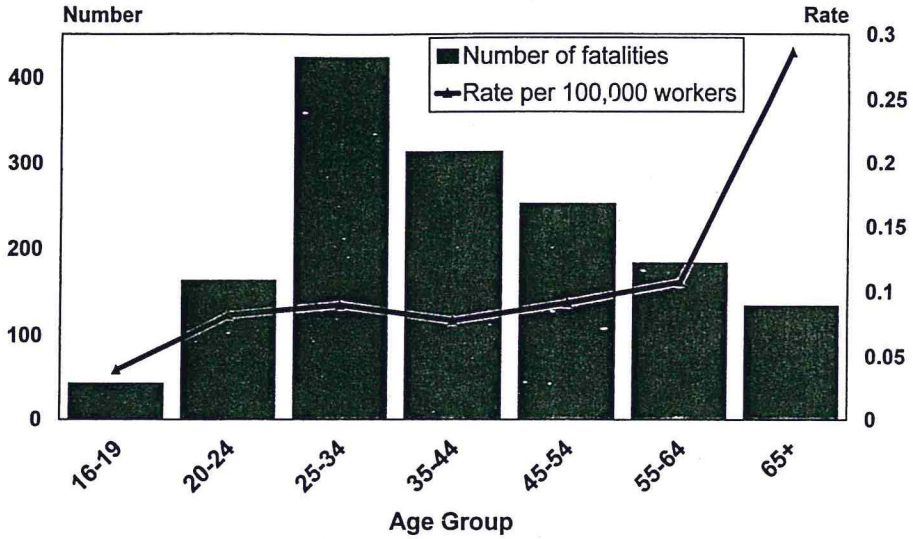

Fig. 3. Number and rate of occupational fatalities due to fire and flames by age group, 1980 through 1994.

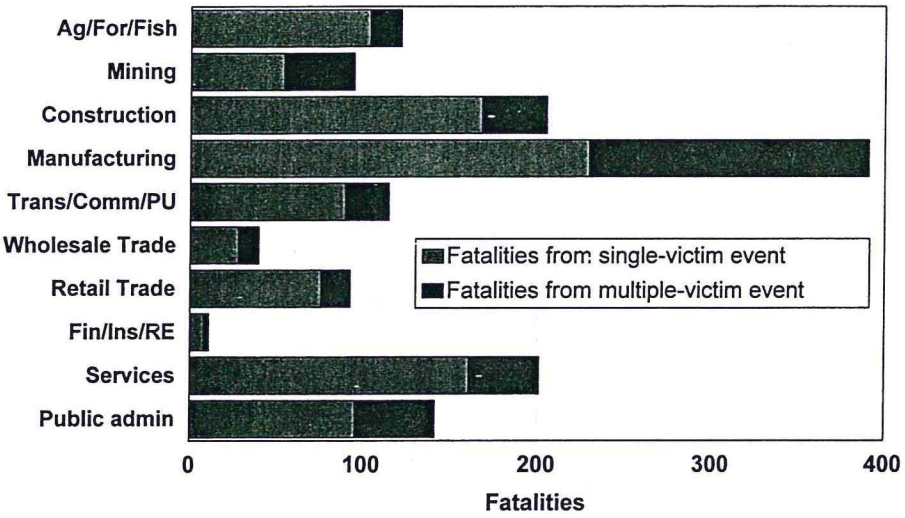

Fig. 4. Number of occupational fatalities for single- and multiple-victim events by industry division, 1980 through 1994.

Louisiana, Texas, and Illinois. By contrast, no multiple-victim event occurred in 16 states over this 15-year period. Because of the close proximity of many occupations within the same work environment, a single incident could involve numerous occupations. Similarly, each incident does not necessarily have decedents from the same industry division. For example, a fire in a manufacturing facility could be responsible for the deaths of the machine operators working in the manufacturing industry as well as sales workers from the wholesale-trade industry who were conducting business at the facility. Therefore, analysis by industry and occupation within these multiple-victim incidents was not conducted. However, the industry and occupation of each victim was examined.

Just over 400 of 1518 fire-related fatalities occurred in a multiple-fatality incident. Of the 419 multiple-victim fatalities, nearly 40% listed the state of death as one of five states–California, Colorado, Louisiana, North Carolina, or Utah. Three of these states not only experienced the highest frequency of fatalities, but also had the highest fatality rates.

The majority, approximately two thirds, of these multiple-victim event fatalities were caused by fires in buildings other than private dwellings, as compared with one third in single-victim-incident fatalities. Fires not in a building or structure, such as forest or grass fires, accounted for the second largest number of multiple-victim incident deaths—60 fatalities, or 14% of the total. In contrast, for single-victim events, this category ranked fourth after ignition of highly inflammable material and private dwelling fires (Fig. 2).

Nearly 4 of 10 of the 419 fatalities resulting from a multiple-victim fire were in the manufacturing industry—almost 3½ times greater than any other single industry division (Fig. 4). Public administration, mining, services, and construction industries each accounted for an additional 10% of multiple-victim fatalities. As was the case for single-victim incident fatalities, the mining industry experienced the highest fatality rate per 100,000 workers, a rate nearly 6 times greater than any other industry division (Fig. 5). Public administration and manufacturing exhibited the second and third highest fatality rates for multiple-victim events, whereas agriculture- forestry-fishing and construction occupied those rank orders for single-victim events.

Forty-three percent of the fire and flame victims who were employed in the mining industry were part of a multiple-victim event. Similarly, within the manufacturing industry, 41% of the fire- and flame-related fatalities resulted from a multiple-victim event. At the other end of the scale, only 15% of the victims who were employed in the agriculture, forestry, and fishing industry were part of a multiple-victim event.

One fourth of the multiple-victim event fatalities listed precision production, craft, and repair as the usual occupation of the deceased (Fig. 6). Three other occupation divisions—service; machine operators, assemblers, and inspectors; and handlers,

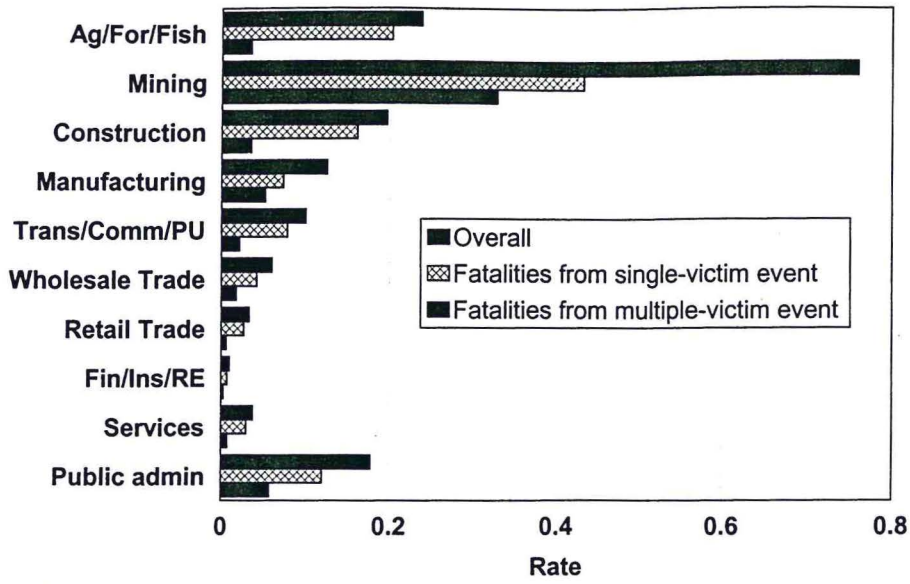

Fig. 5. Occupational fatality rate per 100,000 workers for single- and multiple-victim events by industry division, 1980 through 1994.

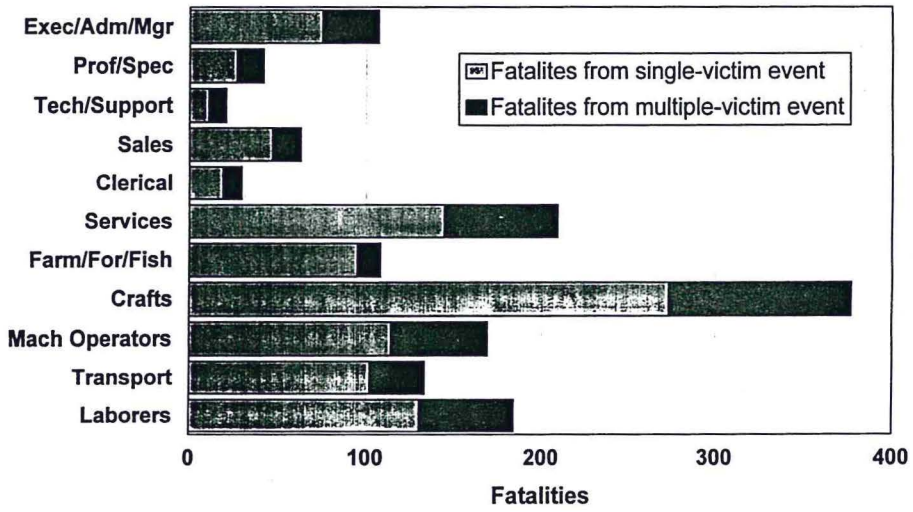

Fig. 6. Number of occupational fatalities for single- and multiple-victim events by occupation group, 1980 through 1994.

equipment cleaners, helpers, and laborers—each contributed about 15% of the total number of multiple-victim event fatalities. Although the proportions differed, the order by frequency of these occupation divisions remained the same as those within single-victim event fatalities. Additional differences can be seen in farming, forestry, and fishing, which represented a substantially larger proportion of the fatalities within single-victim events, 9% compared with 3%.

The highest multiple-victim fatality rate was found in occupations involving handlers, equipment cleaners, helpers, and laborers (Fig. 7). The rate of these occupations was approximately 20 times higher than the lowest rate, which was found in administrative support, including clerical, occupations. Occupations with the greatest disparity between incidence rates of single-victim and multiple-victim events were farming, forestry, and fishing. The rate for single-victim events was nearly 9 times that of multiple-victim incidents.

Of the multiple-victim-incident fatalities, 83% involved male workers and 17% involved female workers. In single-victim-incident fatalities, 94% involved male workers and 6% involved female workers. The distribution by race was comparable between single- and multiple-victim incidents: 78% white and 14% black. The fatality rate for blacks was 1½ times greater than the corresponding rates for whites in both single- and multiple-victim event fatalities.

The largest numbers of victims involved in multiple-victim incidents were found in the middle age groups. Nearly 6 of 10 were between 25 and 44 years old, in contrast to the 45% of victims in this age group who were in single-victim events. The mean age of the victim in a multiple-victim event was 36 as compared with the mean age of 43 for a single-victim event. Unlike the single-victim incidents, for which the highest fatality rate was for the 65+ age group, the highest rates for multiple-victim fatalities were for the 25 to 34 age group. These rates were well over 1½ times higher than that of the 65+ age group in this subset.

Analysis

Findings from this descriptive study refined our understanding of injury-at-work fire- and flame-related deaths by including an analysis of single- and multiple-victim events. This analysis focused on the demographic and employment characteristics of the decedent as well as circumstances surrounding the event.

During the 15-year period studied, just over 1500 workers lost their lives in fire- and flame-related incidents, of which 419 were lost in multiple-victim events. Over this period, the number of fatalities and the number of incidents decreased substantially. Previous work has pointed to the decline in the number of deaths being attributed in part to improved care of burn patients over the past 20 years.[13] Simultaneously, increased sophistication and use of suppression and detection devices have contributed to this downward trend. Functional smoke detectors

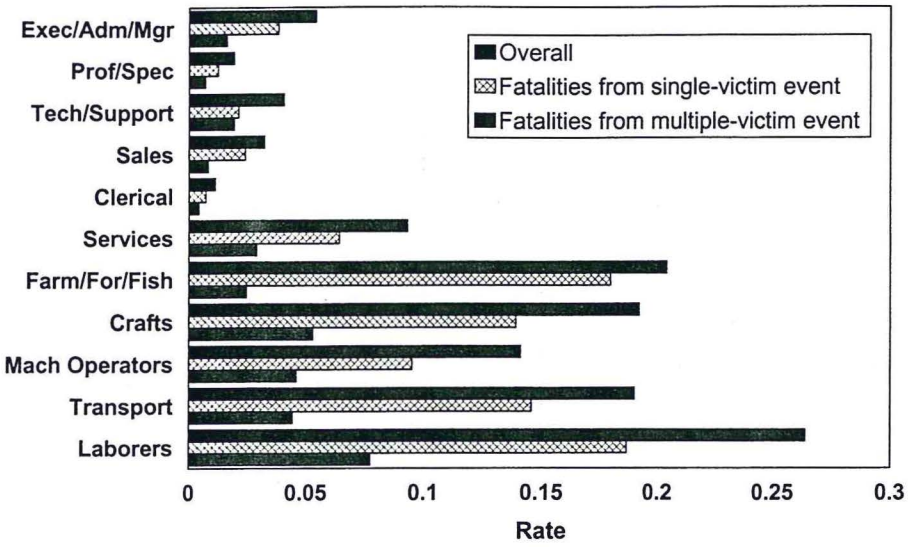

Fig. 7. Occupational fatality rate per 100,000 workers for single- and multiple-victim events by occupation group, 1980 through 1994.

alone can reduce the number of fatalities by nearly 50%.[14]

Overall, the characteristics of the event and the victim involved in a multiple- and single-victim incident were markedly similar. There are two ways to evaluate the impact of incidents—by frequency of occurrence and by rate of occurrence. Frequency measures the number of fatalities within each subgroup, whereas rate of occurrence illustrates the relative level, or risk, of fatalities among different subgroups. Analyzed by frequency, the profile of the decedent for a single- and a multiple-victim-workplace fire was identical. Typically, the decedent was a white man between the age of 25 and 34 who worked in a precision production, craft, and repair occupation and worked within the manufacturing industry.

The nature of the work performed and the work processes within these industries contributed to their higher number of fire and flame fatalities. Manufacturing industries tend to have more conditions that may be hazardous, such as flammable materials, scrap wood and metal chips, oily rags, and other potential ignition sources. Nearly one half of all industrial fires in the United States occur in the manufacturing industry. Many of the precision, production, and craft and repair occupations also tend to work with more hazardous substances and are commonly found in the manufacturing industry.

The large proportion of white workers, ranging from 85% to 90% of the employed civilian workforce, can explain the distribution of fatalities by race. Explaining the higher frequency of male fatalities is somewhat more difficult. Although male workers represent just over one half of the civilian workforce, manufacturing and precision, production, and craft and repair occupations are male-dominated sectors, with 70% and 90% of the workforce being male, respectively.[12]

When examining profiles on the basis of rate of occurrence, one difference between fatalities of multiple- and single-victim incidents came to light—age. The typical fatality from a single-victim industrial fire, by level of risk, involved a black man 65 years of age or older working in the handlers, equipment cleaners, helpers, and laborers occupation group and working in the mining industry. Except that the decedent was between the age of 25 and 34, the profile of a fatality from a multiple-victim incident remained the same.

The much higher fatality rate found in the 65+ age group for single-victim incidents can be partly attributed to their inability to make a rapid successful escape from the fire scene, as documented in a study by Berl and Halpin.[15] This study also suggested that as the age of a worker increases, the mishandling of common workplace ignition sources, such as welding, heating, and cooking devices, may increase. This group also has a decreased tolerance to toxic combustion products, probably owing to a weaker cardiopulmonary system.[15]

The influence of cultural roles has been presented as a possible rationale for the higher rate of male fatalities associated with fires. The National Fire Protection Association reported that, during a fire, men more frequently conduct investigation and firefighting activities than do women. Women more commonly engage in warning and evacuation activities.[16]

The higher risk of those employed in the mining industry may result from limited means of egress, extended travel distance required to reach safety, and dimly lighted exit routes. Escape can also be hindered by poor visibility caused by dense smoke and associated poor air quality that results in breathing difficulties.[17] A large number of fatalities were found in the oil and gas extraction industries. The sheer magnitude of the explosions from volatile materials found in this industry may contribute to the increased number of fatalities. However, additional research to determine more precise causal factors is needed.

Discussion

This study examined the characteristics of single- and multiple-victim fire- and flame-related events with the intent to make recommendations specific to each category of event. Results from this study did not reveal differences between these two event categories substantial enough

to warrant other than general recommendations. Defining specific prevention efforts can be accomplished by conducting similar studies using other data sources and variables. Potential data sources include the NIOSH Fire Fighter Fatality Investigation and Prevention Program, the International Association of Fire Fighters, and OSHA. Suggested variables include source of ignition, detection and suppression systems employed, medical cause of death, and type of work or work process associated with the firm. Behavioral variables such as usual worker activity versus activity at the time of incident, human behavior responses and actions in fire incidents, and the firm's commitment to fire safety through policy and practice may provide data to support the development of more focused prevention strategies.

General recommendations to reduce the risk of fatality examined in this study fall into three broad categories: prevention, detection and suppression, and amelioration. The fact that almost two thirds of the multiple-victim and one third of the single-victim deaths resulted from fires in buildings points to building safety as a key issue in prevention efforts. Employers can eliminate and prepare for job-related fires, including those in buildings, by writing and implementing fire prevention plans as described in Title 29 Code of Federal of Regulations Part 1910.38. A fire prevention plan is designed to avert losses associated with fire, such as loss of life, property, and production. A comprehensive plan must address the following elements: fire hazards, housekeeping, training, and maintenance.[18]

Detection and suppression include measures undertaken and equipment used to detect, confine, and extinguish a fire. Many of the multiple-victim events occur in facilities with inadequate detection or suppression systems.[19] Smoke and heat detection devices are relatively inexpensive and provide an invaluable service during a fire emergency. Title 29 Code of Federal Regulations 1910.164(f) suggests that an adequate number of these devices is necessary to provide early warnings throughout the facility. Suppression equipment is equally as important as detection devices and should not be overlooked when developing a fire plan. The fact that automatic sprinklers often are the first line of defense against the spread of potentially fatal fires illustrates this point.[18]

Amelioration efforts are implemented to minimize the extent of the injury attributable to a fire. As a complement to a fire prevention plan, an emergency evacuation plan should be developed and practiced.[18] Prompt evacuation from the premises and notification of the fire department could have prevented many of the multiple-victim events from occurring. In a 1991 study by Miller and Tremblay, the absence of operating smoke detectors and sprinklers, delays in fire department notification, and blocked or illegally locked exits were cited as contributors to most multiple-victim events.[20] Many of the victims in these incidents died making their attempted escape through the primary route of exit. Fatalities could have been avoided if workers had used alternative routes of exit.

Many sources provide guidance for developing strategies to prevent fire- and flame-related deaths in the workplace. For instance, the National Fire Protection Association, organized in 1896, promotes and improves methods of fire protection and prevention by establishing codes, standards, and recommended practices and guides within the Life Safety Code (NFPA 101).[21] OSHA, a regulatory agency established under the Occupational Safety and Health Act of 1970, stipulates the employer-based legal requirements for means of egress and fire safety plans in Title 29 Code of Federal Regulations 1910.[18] To foster a safer work environment for every American worker, employers should be thoroughly familiar with these codes and standards. "Fire protection and fire prevention are two vital responsibilities for safety professionals."[22]

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1900	1999 (est)
New York	New York
Chicago	Los Angeles
Philadelphia	Chicago
St. Louis	Houston
Boston	Philadelphia
Baltimore	San Diego
Cleveland	Phoenix
Buffalo	San Antonio
San Francisco	Dallas
Cincinnati	Detroit

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