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BRIEF COMMUNICATIONS AND RESEARCH NOTES

FATAL OCCUPATIONAL FALLS IN THE U.S. CONSTRUCTION INDUSTRY, 1980–1989

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Abstract—Death certificate analyses were conducted on all fatal occupational falls occurring between 1980 and 1989 in the United States' construction industry using the National Traumatic Occupational Fatalities surveillance system at the National Institute for Occupational Safety and Health, Division of Safety Research. Fatality rates were calculated by geographic location (region and state), and year of injury. From 1980 to 1989, there were 2798 deaths due to occupational falls in construction, representing 49.6% of all fatal occupational falls across all industries. Most of these incidents occurred among young white males. By geographical location, the highest fatality rates were observed within the subregions of the Southern states in the United States. In observing the time between the date of injury and the date of death, 66% of the fall victims died on the same day as the injury, whereas 5.7% lived more than 90 days before dying. Further research needs to be targeted at what occupations are at highest risk for a fall injury, what circumstances are attributable to these falls, and prevention strategies to reduce fall injuries and fatalities. Research is also needed to explain why there are geographic differences in occupational falls in the construction industry. Copyright © 1996 Elsevier Science Ltd

Keywords—Occupational falls, Fall injury, Construction, Falls

INTRODUCTION

The construction industry has been identified as one of the most hazardous industries in the United States, and occupational falls have been identified as the most common cause of fatal injury in the industry (National Safety Council 1989; United States Department of Labor 1990; Bell et al. 1990; National Institute for Occupational Safety and Health 1993; Kisner and Fosbroke 1994). In order to adequately develop and implement effective strategies for preventing fatal falls, workers at high risk for occupational falls must be identified, and factors associated with fall injuries must be determined. The magnitude of these fatal occupational fall injuries is a major public health concern.

Background information

The construction industry represents 5% of the nation's workforce and ranks among the top three most hazardous industries in the United States in terms of occupational injuries and fatalities (National Safety Council 1991; United States Department of

Labor 1990; Bell et al. 1990; National Institute for Occupational Safety and Health 1993; Kisner and Fosbroke 1994). Unlike other industries, the construction industry is difficult to study due to its complexity and diversity in job tasks, skilled workforce, climatic conditions and work environments. Most construction projects can be characterized by the temporary and transitory nature of both the workplace and workforce. In this industry, the workplace changes daily and the type of work varies greatly, from new construction, repairs or renovations to existing facilities, demolition of buildings and structures, and hazardous waste abatement to cleanup and reconstruction following natural disasters. The workforce of construction firms are usually transitory employers of local temporary employees. The turnover of employees in this industry have been estimated at about 200% per year (West Virginia University Research Corporation 1990). It has also been noted that more new and inexperienced persons are being hired in the industry when higher levels of skill are required (West Virginia University Research Corporation 1990). The effect these employment practices will have on occupational injuries in this industry is unknown.

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According to the Bureau of Labor Statistics (BLS), the construction industry had the highest incidence rate of work-related injuries in 1988 (United States Department of Labor 1991). It has been estimated that 14 out of every 100 full-time construction workers suffer an injury serious enough to require medical care each year (United States Department of Labor 1991; Vossen 1990). Workdays lost to injuries on the job more than doubled from 2.5 million in 1972 to over 6.3 million in 1988. The 6.3 million days lost from work in 1988 in the construction industry were shared by a little more than 40,000 construction workers, implying workers averaged losing 157 days each from work in 1988 (Vossen 1990).

Occupational falls are the third most common type of injury producing event found across all industries in both the United States (National Safety Council 1989) and Canada (Alberta Community and Occupational Health 1990). Fall injuries are usually classified as occurring from an elevated work surface (e.g. ladders, scaffolds, roofs, buildings, stairs, vehicles, into an opening, etc.) or from the same level. This report primarily focuses on occupational falls in the construction industry, where 87.9% were known to be due to a fall from one level to another. Falls from elevation, the most common type of fall (United States Department of Labor 1990; Center for Excellence in Construction Safety 1991; Cohen and Compton 1982), are incidents in which a worker falls from one level to a lower level and is injured on impact against an object or the ground. Most of these injuries include fractures, sprains, strains, contusions, damage to internal organs, and death (Keyserling 1988). The nature and severity of fall injuries are dependent on the velocity and orientation of the worker at the time of impact (Keyserling 1988; Goonetilleke 1980). According to the literature, over 40% of all falls from elevation occur in the construction industry, where work activities are frequently performed on temporary working surfaces that are exposed to a variety of environmental conditions including rain, snow and ice. Other reasons that falls may occur from elevated scaffolds, walkways, and/or work platforms are because of insufficient or non-existent guardrails or personal fall protection systems (Keyserling 1988; National Institute for Occupational Safety and Health 1990, 1992).

The purpose of this report is to identify the demographics of the United States' construction workers who were fatally injured due to an occupational fall. Information such as age, race, marital status, year of injury, geographic area, injury information, and the survival period between injury and death are presented.

METHODS

The analyses of construction-related fall injuries in this paper are based on the information reported on the death certificate. For the 10-year study period (1980–1989), the National Traumatic Occupational Fatalities (NTOF) surveillance system which contains death certificate information was used to analyze the demographic characteristics of decedents whose usual industry of employment was in the construction industry and whose cause of death was reported as a fall injury. The variables reviewed for these analyses from the NTOF surveillance system included age, race, sex, marital status, date of birth, date of death, date of injury, injured at work, state of residence, state of death, county of residence, county of death, and external cause of death via the International Classification of Diseases, Ninth Revision (ICD9) (World Health Organization 1977). The NTOF surveillance system compiles death certificate data on work-related deaths from the 52 separate vital statistics reporting units in the United States, consisting of one within each state government, New York City, and the District of Columbia.

Study population

All cases were aged 16 and older, the usual occupation was in the construction industry, the date of injury was between 1980 and 1989, the cause of death was due to injuries sustained from an occupational fall (ICD9, E880-888) (World Health Organization 1977), and they were classified as injured at work on the death certificate.

Data sources

Two data sources were used to conduct the analyses: the National Traumatic Occupational Fatalities (NTOF) surveillance system (National Institute for Occupational Safety and Health 1980-1989, data base) for the numerator data and the County Business Patterns (CBP) (United States Department of Commerce 1980-1989, data tapes) for the denominator data. Description of the NTOF surveillance system and its limitations are described elsewhere (National Institute for Occupational Safety and Health 1993). The CBP database was used to ascertain denominator data in the construction industry to generate state-specific fatality rates. The CBP data is extracted from the Bureau of the Census Standard Statistical Employment List (SSEL) and includes the mid-March estimate on the number of employees in the industry (United States Department of Commerce 1980-1989, data tapes). CBP does not stratify the employees by age, race or sex.

Data analyses

Demographic information about persons who sustained a fatal occupational fall in the construction industry was analyzed. Due to the instability of rates based on small numbers of deaths, state-specific fatality rates were not calculated where there were less than three deaths as stated elsewhere in reference to this surveillance system (National Institute for Occupational Safety and Health 1993).

The 10-year state-specific fatality rates per 100,000 workers were calculated by using the following formula:

$$F_R = \frac{F_N}{E_{TC}} \times 100,000 \text{ construction workers where}$$

F_R = fatality rate for 1980–1989

F_N = number of occupational fall fatalities in a specific group during 1980–1989

E_{TC} = total number of construction workers in the specific group during 1980–1989.

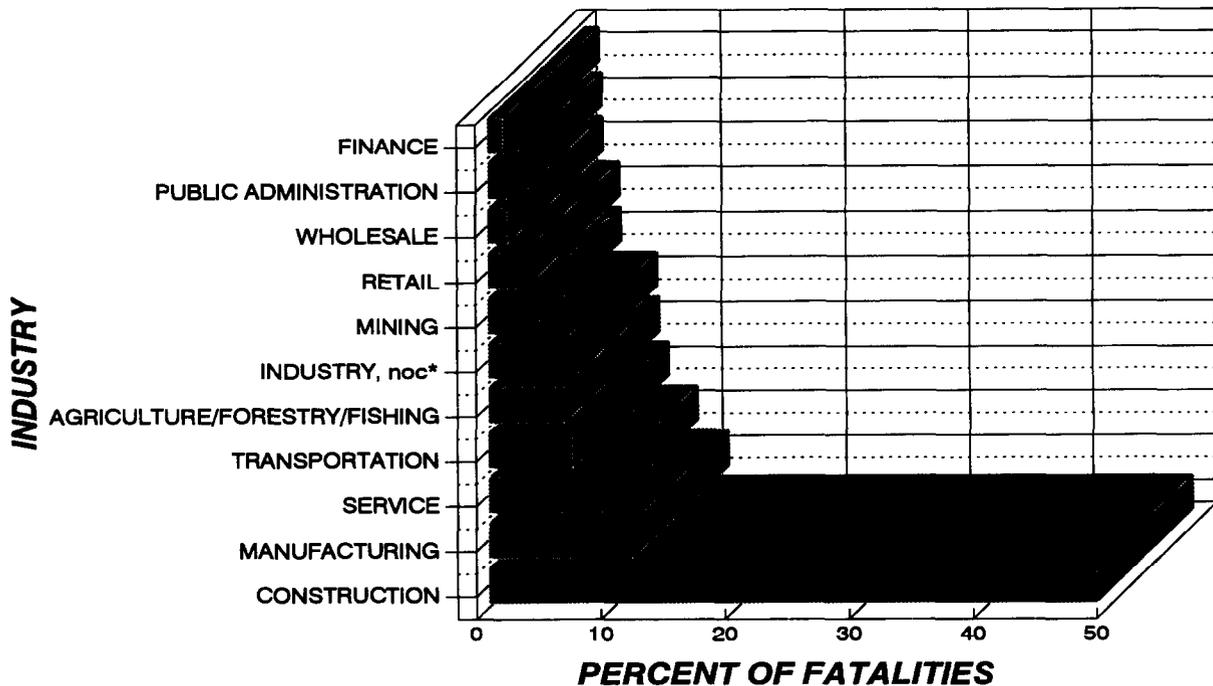
RESULTS

Between 1980 and 1989, the NTOF surveillance system revealed that 49.6% of all United States occu-

pational fall fatalities occurred in the construction industry (Fig. 1). There were 2798 construction death certificates which met the study criteria specified in the Methods section.

Demographic information

Of the 2798 fatal occupational fall cases, the age at death ranged from 16 to 89 years with a mean age of 40.3 years (Table 1). Therefore, these persons were still considered in the workforce at the time of their demise. Over half (52.7%) of these fatalities occurred to construction workers aged 39 years or less. In addition, 81.1% were white, 64.0% of the decedents were married at the time of death, and 99.6% of this population were males. Further analyses are being conducted to review the fatality rates by race, sex and age and will be presented in a manuscript that focuses on the occupational information of these decedents. Most of the decedents' state of residence at the time of death was reported either as Texas (343 workers or 12.3%), California (230 workers or 8.3%), Florida (212 workers or 7.6%), Illinois (170 workers or 6.1%), Pennsylvania (149 workers or 5.3%), or New York (143 workers or 5.1%). When comparing the state where the death occurred to the state of residence, it



*noc=not otherwise classified
(N_{Construction}=2798)

SOURCE: CDC, NIOSH, DSR, 1980 TO 1989 NTOF Surveillance System.

Fig. 1. Distribution of U.S. occupational falls by industry.

Table 1. Demographic information on decedents of occupational falls in the U.S. construction industry, 1980–1989

	N	(%)
Number of cases	2798	100.0
<i>AGE (YEARS):</i>		
16–19	81	2.9
20–24	345	12.3
25–29	406	14.5
30–34	374	13.4
35–39	268	9.6
40–44	252	9.0
45–49	233	8.3
50–54	252	9.0
55–59	265	9.5
60–64	187	6.7
65+	134	4.8
<i>RACE:</i>		
White	2269	81.1
Black	225	8.0
American Indian	18	0.6
Asian	26	0.9
Hispanic	190	6.8
Unknown	3	0.1
Missing	66	2.4
<i>MARITAL STATUS:</i>		
Married	1792	64.0
Widowed	47	1.7
Divorced	353	12.6
Never married	598	21.4
Unknown	8	0.3
<i>SEX:</i>		
Male	2788	99.6
Female	10	0.4

Table 2. Frequency and annual fatality rates for occupational falls in the U.S. construction industry

Year of death	N	(%)	Fatality rate
1980	304	10.9	6.8
1981	304	10.9	7.1
1982	258	9.2	6.5
1983	257	9.2	6.8
1984	269	9.6	6.4
1985	303	10.8	6.8
1986	257	9.2	5.5
1987	270	9.6	5.3
1988	310	11.1	6.3
1989	266	9.5	5.3
U.S. 1980–1989	2798	100.0	6.2

was revealed that 2459 decedents (87.9%) died in the same state as his/her residence, 231 (8.3%) died in an adjacent state, and 108 (3.8%) died in a non-adjacent state. Construction workers may have died in an adjacent state due to the location of trauma centers or the nearest hospital to the injury site.

The number of fall fatalities varies from month to month as one would expect due to the general seasonality of construction. Seventy-one percent of these fall fatalities occurred between March and October when construction activities in most seasonal

areas are prevalent. By season, 54% of the fall fatalities occurred during spring and summer, 27% during autumn and 19% during winter. When the fatal injuries were analyzed by the day of week of injury, there was no significant pattern to the fall injuries. Seventy-six percent of the fall incidents occurred during the normal work hours between 6 a.m. and 5 p.m. and 91% occurred during a 5-day work week (Monday through Friday) and not on the weekend, as one might expect if overtime was a crucial factor during peak construction periods.

Fatality rates: geographical location

The number of occupational fall fatalities ranged from 256 to 309 per year with a mean of 279.2 deaths per year. The overall U.S. fall fatality rate for the 10-year study period was 6.2 per 100,000 construction workers. The annual fall fatality rate declined slightly from 6.8 in 1980 to 5.3 in 1989 (Table 2) as the United States construction workforce increased from 4.5 million in 1980 to 4.9 million workers in 1988. Variation in state-specific fall fatality rates greater than the national average ranged from 6.3 per 100,000 workers in Alabama to 15.6 per 100,000 workers in the District of Columbia (Table 3). These analyses provide more detailed information to that presented in the NTOF Atlas (National Institute for Occupational Safety and Health 1993). Information pertaining to state-specific injuries within an industry cannot be ascertained from the NTOF Atlas. For example, in the NTOF Atlas, the average annual fatality rate (per 100,000 workers) for fall-related fatalities is divided into four categories: moderately low, moderately high, high, and very high. The categories were classified as follows (National Institute for Occupational Safety and Health 1993):

- **Moderately low** (0.3–0.6) were fatality rates considered less than the average rate and was less than one standard deviation below the average.
- **Moderately high** (0.7–1.1) were fatality rates considered greater than the average rate but less than one standard deviation above the average.
- **High** (1.2–1.5) were fatality rates considered greater than one standard deviation above the average rate but less than two standard deviations above the average.
- **Very high** (> 1.5) were fatality rates more than two than two standard deviations above the average.

According to the NTOF Atlas, states such as Alabama, Kentucky, and the District of Columbia had an overall fall fatality rate between 0.7 and 1.1. From this information, one would assume that fall fatalities is not a major problem in these states.

However, if one were to focus on the construction-related fall fatalities in the states, it becomes quite apparent that falls are a major problem. The overall construction-related fall fatality rate for these states (per 100,000 workers) is twice as high as the South geographical region rate of 6.8 and the national rate of 6.3 (Table 3).

By region, the Northcentral had lower fall fatality rates than all other regions. The West had lower rates than the South. Comparison of subregion differences indicate that in the South region, the South Atlantic states are significantly lower than the West South Central states. Within the Northeastern region, the New England states had significantly lower rates than the Middle Atlantic states. Individual state-specific fatality rates based on the state of death are also provided in Table 3.

Injury information: type of work surfaces involved in fatal falls

Construction workers fell from a building or structure in 40.8% of the cases. The other leading work surfaces were scaffolds (18.6%), and ladders (11.0) (Fig. 2). Falls from all other elevated work

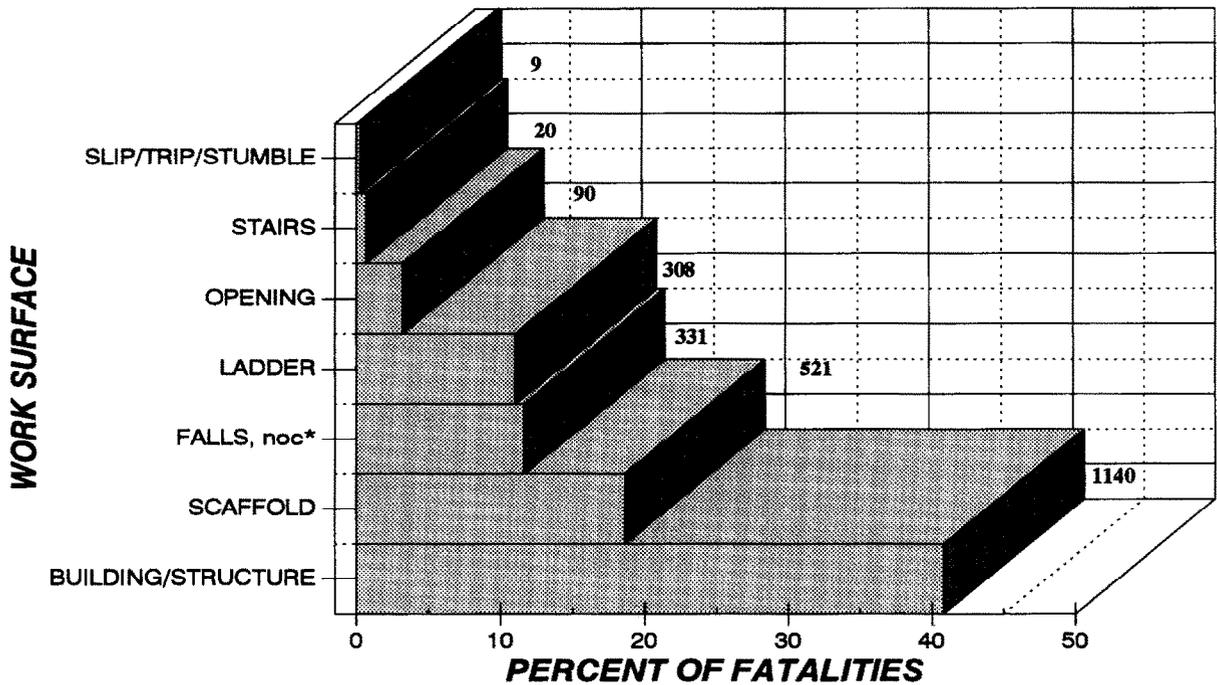
surfaces not otherwise classified according to the ICD9 E-code categories accounted for 11.8% of these fatalities.

Fatal variation following the occupational fall injury

In considering the number of days between the date of the injury and the date of death, 66% of workers injured from an occupational fall died within 24 hours of the injury, 19.1% died within seven days of the injury, 9.2% died within 90 days of the occupational fall, and the remaining 5.7% died more than 90 days from the date of injury (Fig. 3). Of the persons who died more than 90 days after the fall injury, the number of days ranged from 93 to 3813 days (equivalent to 10.4 years.) Of this subgroup, 97.6% had died within 1407 days (equivalent to 3.8 years) of the injury. Ninety-nine percent of the total study population had died within one year of the fall injury.

DISCUSSION AND CONCLUSION

These analyses highlight the magnitude of occupational falls within the construction industry.



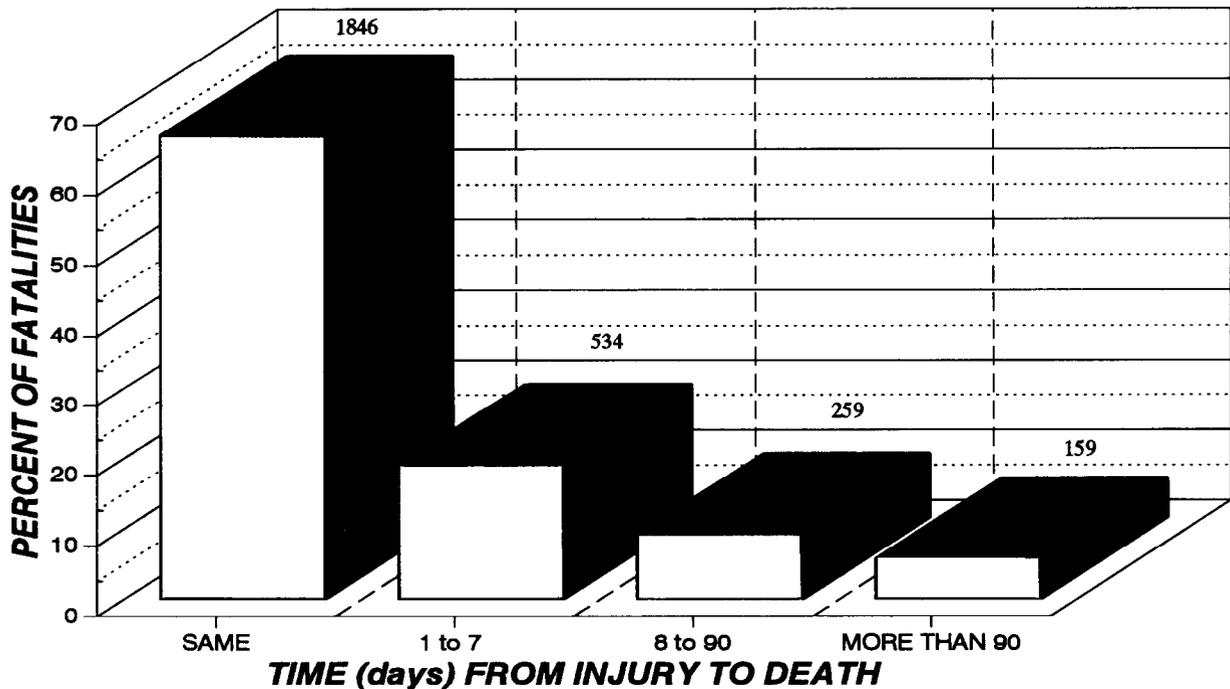
*noc=not otherwise classified (N=2798)

SOURCE: CDC, NIOSH, DSR, 1980 to 1989 NTOF Surveillance System. (Based on ICD-9 E-codes)

Fig. 2. Distribution of working surface from which the fall occurred, U.S. construction industry.

Table 3. Occupational fall fatalities in the U.S. construction industry by geographical area: 1980-1989

Geographical area	Region	State	Deaths	Population	Rate
South	South Atlantic		1234	18181933	6.8
			591	9626944	6.1
		District of Columbia	14	90028	15.6
		Delaware	6	168785	3.6
		Florida	226	2989622	7.6
		Georgia	90	1242003	7.2
		Maryland	36	1273529	2.8
		North Carolina	84	1311744	6.4
		South Carolina	48	1009475	4.8
		Virginia	73	1336926	5.5
	West Virginia	14	204832	6.8	
	East South Central		181	2440475	7.4
		Alabama	49	775949	6.3
		Kentucky	43	480734	14.1
		Mississippi	21	352776	13.9
		Tennessee	68	831016	2.5
	West South Central		462	6114514	7.6
		Arkansas	23	315413	7.3
		Louisiana	46	1054183	4.4
		Oklahoma	35	485275	7.2
Texas		358	4261391	8.4	
Northeast	Middle Atlantic		463	8177999	5.7
			354	5778136	6.1
		New Jersey	74	1323985	5.6
		New York	152	2490813	6.1
	New England		128	1963338	6.5
			109	2399863	4.5
		Connecticut	14	628390	2.2
		Massachusetts	56	1048443	5.3
		Maine	15	207346	7.2
		New Hampshire	14	246467	5.7
		Rhode Island	4	157131	2.5
		Vermont	6	112086	5.4
	North Central	East North Central		612	16239538
			417	13442253	3.1
Illinois			167	1724103	9.7
Indiana			72	8455406	0.9
Michigan			61	1094094	5.6
West North Central			84	1525794	5.5
		Wisconsin	33	642856	5.1
			195	2797285	7.0
		Iowa	39	354302	11.0
		Kansas	21	421094	5.0
		Minnesota	43	703232	6.1
		Missouri	58	886287	6.5
		Nebraska	18	255448	7.0
North Dakota	10	97079	10.3		
South Dakota	6	79843	7.5		
West	Pacific		489	9645346	5.1
			344	6712960	5.1
		Alaska	5	122006	4.1
		California	236	5188673	4.5
		Hawaii	19	209627	9.1
		Oregon	28	370565	7.6
	Mountain		56	822089	6.8
			145	2932386	4.9
		Arizona	30	871568	3.4
		Colorado	43	792821	5.4
		Idaho	8	158170	5.1
		Montana	9	102711	8.8
		Nevada	20	298441	6.7
		New Mexico	7	326205	2.1
		Utah	18	273435	6.6
Wyoming	10	109035	9.2		
United States			2798	52244816	6.2



SOURCE: CDC, NIOSH, DSR, 1980 to 1989 NTOF Surveillance System.

Fig. 3. Time variation between date of injury and date of death, U.S. construction-related occupational falls.

Occupational fall fatalities occurred most frequently from buildings (40.8%), in the South (44.1%), and resulted in death within 24 hours of the injury (66%). Most of these fatalities are occurring among young white males. The average years of potential life lost (YPLL) before age 66 (National Institute for Occupational Safety and Health 1989, 1993) due to death was 24.9 years for the study population. The YPLL for each fatal case was determined by subtracting the victim's age at the time of death from the potential retirement age of 65 years (National Institute for Occupational Safety and Health 1993). Approximately 43.2% of these fatally injured workers were under 35 years of age and lost 34–49 years of their potential work life due to a fatal occupational fall.

The literature indicates that most of these fatal fall injuries could have been prevented, or at least, been less severe, through use of proper personal fall protective equipment, such as lifelines and lanyards, employee training in fall prevention, and management implementation and enforcement of fall protection and prevention measures at the jobsite (National

Institute for Occupational Safety and Health 1990, 1992).

These analyses should alert occupational safety and health professionals to the need to identify the circumstances and multiple causes involved in these types of fall events, in addition to factors affecting the non-use of personal fall protective equipment and other fall prevention strategies. Further research needs to be targeted at what workers are at highest risk for this type of injury/fatality, what types of circumstances are attributable to these falls and what preventive strategies are necessary to reduce these injuries and fatalities. Research is also needed to further address the geographical differences associated with fatal falls in construction and the possible reasons for the differences, such as the economy, the type of equipment used, weather conditions, job experience, components of safety and health programs, etc. To further address some of these issues, a closer investigation of construction-related fall injuries and potential risk factors has been conducted in a case-series study design in West Virginia and the data is being analyzed. Further research will be conducted to assess these

risk factors in a case-control study design. Intervention methods need to be identified and implemented to improve workplace safety and health for all employed in the construction industry, and especially for those who work from elevated surfaces.

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