External Cause-Specific Summaries of Occupational Fatal Injuries. Part I: An Analysis of Rates

A. John Bailer, PhD,[1,2]* **James F. Bena, MS,**[2] **Leslie T. Stayner, PhD,**[2]
William E. Halperin, MD, DrPH,[2,3] **and Robert M. Park, MS**[2]

Background *Industries and occupations vary with respect to the incidence of fatal injuries and their causes.*

Methods *Fatalities from the National Traumatic Occupational Fatality database (years 1983–1994) serve as the basis for examining external cause of death code specific rates. Industries and occupations are compared with respect to rate and frequency of fatal injuries. In addition, external causes of injury (E-codes) are examined across all industries and occupations as well as within industries and occupations to evaluate which events would be identified by frequency ordered comparisons versus injury rate ordered comparisons.*

Results *Machinery, electric current, homicide, falls, and transportation-related events are identified by high frequency and rate of occurrence.*

Conclusions *The external cause categories of homicide, machinery-related, motor-vehicle-related, electric current, and falls, account for over one-half of all occupational fatal injuries. Targeted interventions in homicide may be especially warranted in sales and service occupations and in the retail trade and services industries. In addition, younger workers might be targeted for special interventions designed to identify hazardous practices, procedures, and solutions to reduce fatalities associated with electrocution or falls from buildings.* Am. J. Ind. Med. 43:237–250, 2003. *Published 2003 Wiley-Liss, Inc.*[†]

KEY WORDS: E-codes; electrocution; fall injuries; machine injuries

INTRODUCTION

Approximately 6000 U.S. workers died each year between 1980–1995 due to occupational fatal injuries [NIOSH, 1993; Toscano and Windau, 1993; Toscano and Windau, 1994; Stout et al., 1996; Herbert and Landrigan, 2000; Marsh and Layne, 2001]. The frequency of non-fatal injuries are orders of magnitude larger than fatal occupational injury counts. For example, in a surveillance report of injuries in the mining industry over years 1986–1995, injuries in coal miners occurred at a rate of 38.9 fatal injuries per 100,000 workers while non-fatal injuries occurred at a rate of approximately 10 per 100 workers [NIOSH, 2000]. Toscano [1997] reported 6210 fatal injuries and 2,252,600 non-fatal injuries in all occupations based upon 1995 data collected by the Bureau of Labor Statistics Census of Fatal Occupational Injuries (CFOI) and Annual Survey of Occupational Injuries and Illnesses (ASOII).

A variety of indices can be used to examine the impact of injuries. For fatal injuries, fatality frequency/count or rates are commonly examined [Leigh, 1995; Toscano, 1997; Bailer et al., 1998]. Counts can be analyzed in a relative

manner by comparing the percentage of fatal injuries occurring in an occupation relative to the percentage employed in an occupation [Toscano and Windau, 1993]. In addition, other indices can be derived from these values such as the index of relative risk, the ratio of the fatal injury rate for a particular group relative to the rate for all workers [Toscano, 1997]. Rates can be constructed relative to employment counts or hours worked which can have a noticeable impact for younger or older workers [Ruser, 1998]. Years of potential life lost is another index that can be examined for fatal injuries [Gilbert et al., 1998]. For non-fatal injuries, indices of impact often reflect time away from work or days required to recuperate from an injury [Toscano, 1997]. Finally, cost has been suggested as a means for ranking occupations relative to the impact of workplace injuries and illnesses [Leigh and Miller, 1997].

We explore patterns of injury events along with metrics of impact within different external causes of death [ICD9 E-codes, U.S. Dept. of Health and Human Services, 1991]. This article is intended to be a descriptive survey that will help identify intervention targets. Note that the recent report by Marsh and Layne [2001] also addresses occupational fatal injury rates stratified by industries and occupations. In this article, we do not replicate this broad survey. We present occupational fatal injury rates for industries and/or occupations with the highest fatality rates—a series of "top 10" lists. In addition, we describe the most common specific external cause of death codes within industries and occupations. In a companion paper, Bailer et al. [2003] we examine external cause-specific impact on years of potential life lost (YPLL). While other papers have considered external causes and fatal injuries [e.g., Toscano and Windau, 1993; Toscano and Windau, 1994; Stout et al., 1996], we report occupational injury rates at a much finer grouping of external causes of death than has previously been reported.

METHODS

Data and Rate Construction

The occupational fatal injury data considered in this analysis come from the National Institute for Occupational Safety and Health's (NIOSH) National Traumatic Occupational Fatal (NTOF) injury data set [NIOSH, 1993]. The NTOF database is a death certificate based registry of occupational fatal injuries in the U.S. containing information about each fatality on age, gender, race, industry division [Standard Industrial Codes, OMB, 1987], and occupation division within an industry [Census codes, US Dept. of Census, 1982], and E-code/external cause [ICD9, U.S. Dept. of Health and Human Services, 1991] for years 1983–1994. Examples of the types of jobs in the different industries and occupations are given in the Appendix. The NTOF database has a number of inclusion criteria including: 1) a minimum

age of 16 years; 2) the death certificate notes that the injury occurred at work; and 3) injury was listed as a cause of death based on the ICD codes. Observations from the NTOF database were included to the greatest extent possible. For example, an observation with no occupational code but all other fields was included for all calculations except those involving summary by occupation. Observations with no external cause or age at death were excluded from all calculations. The NTOF data provides numerator data for the rate calculations. Denominator data for the rate calculations were based on BLS employment data. These were unpublished data tabulated from the current population survey [U.S. Bureau of the Census, 1978] constructed in response to an interagency agreement between BLS and NIOSH.

These numerator data of occupational injuries provide a sense of the magnitude of the impact on public health. Rate calculations were constructed as counts of fatalities per year scaled by estimates of the number of workers employed. Rates were generally reported on a per 100,000 worker-years basis.

External Cause of Death Considerations

The external cause of death categories reflect a hierarchical structure where codes are specified for a particular circumstance or for an unspecified/other category, a "catch all" for cases with insufficient detail to allow for finer description. As an example, the unspecified category accounts for over 90% of cases in the air transport accidents group. Most of the other subgroups are of minimal, even negligible concern except for accidents during takeoff or landing. Many cases classified into the unspecified group could have been classified into more specific E-codes if additional information had been available, however, this does not preclude the use of the more detailed codes.

RESULTS

Construction and transportation/public utilities were the industries with the highest *numbers* of injury deaths while wholesale trade and finance/insurance/real estate had the lowest number of fatal injuries (Table I). Mining and agriculture/forestry/fishing had the highest *rates* of fatal injury, 26.2 and 19.3 per 100,000, respectively, and services and finance/insurance/real estate had the lowest rates, 1.6 and 1.1 per 100,000, respectively.

Precision, production, crafts and repair, and transportation and material moving were the occupations with the highest number of fatalities while technicians and related support along with clerical and administrative support had the lowest number of occupational fatalities (Table II). The transportation and material moving fatal injury rate was 21.6

TABLE I. Industries Ordered by Number of Deaths and Death Rates Per 100,000 Workers for Occupational Fatal Injuries Occurring in Years 1983−1994

	Deaths	Rate
Industry		
Construction	12,408	14.3
Transportation/public utilities	11,830	12.4
Manufacturing	9,472	3.8
Agriculture/forestry/fishing	7,834	19.3
Services	7,255	1.6
Retail trade	6,048	2.6
Public administration	4,854	7.6
Mining	2,476	26.2
Wholesale trade	1,673	3.1
Finance/insurance/real estate	963	1.1
Total for industries	64,813	4.8

deaths per 100,000, farming, forestry and fishing exhibited 20.2 deaths per 100,000, while clerical and administrative support occupations exhibited 0.6 per 100,000.

Table III presents industry/occupation levels ordered in terms of numbers of fatal injuries and injury rates. Transportation industry and occupation along with agriculture, forestry and fishing industry, and occupation and construction/crafts each had over 6000 fatal injuries over the years of this study. Manufacturing/farm, forestry and fishing exhibited a death rate of 137/100,000 workers. This industry/occupation combination was mainly comprised of loggers working for pulp and paper product manufacturers or milling operations.

TABLE II. Occupations Ordered by Number of Deaths and Death Rates Per 100,000 Workers for Occupational Fatal Injuries Occurring in Years 1983−1994

|	Deaths	Rate
Occupation		
Precision production, crafts, and repair	13,128	8.2
Transportation and material moving	12,294	21.6
Farming, forestry and fishing	8,457	20.2
Laborers	7,662	13.7
Service	4,834	2.6
Executives, administration and managers	4,806	2.9
Sales	4,410	2.7
Machine operators, assemblers and inspectors	2,735	2.9
Professional specialty	2,661	1.5
Technicians and related support	1,816	4.2
Clerical and administrative support	1,313	0.6
Total for occupations	64,116	4.7

TABLE III. Industry/Occupation Combinations Ordered by Number of Deaths and Death Rates for Occupational Fatal Injuries

Industry/occupation	Deaths	Rate per 10^5
a. Industry/occupation combinations ordered by number of deaths for occupational fatal injuries occurring in years 1983−1994		
Transportation/transportation	7,158	33.8
Agriculture, forestry, fish/ farm, forestry, fish	6,719	19.5
Construction/crafts	6,133	12.3
Construction/laborers	3,295	34.0
Retail/sales	2,953	3.1
Manufacturing/crafts	1,925	4.1
Public administration/service	1,888	11.9
Manufacturing/machine operators	1,731	2.2
Services/professional specialty	1,538	1.1
Construction/transportation	1,519	25.3
Total for industry/occupations	62,604	4.6
b. Industry/occupation combinations ordered by death rates per 100,000 workers for occupational fatal injuries occurring in years 1983−1994		
Manufacturing/farm, forestry, fish	1,495	137.0
Agriculture, forestry, fish/laborers	188	73.7
Mining/laborers	215	55.2
Mining/crafts	1,384	45.1
Agriculture, farm, fish/ transportation	268	44.9
Construction/laborers	3,295	34.0
Transportation/transportation	7,158	33.8
Public administration/laborers	180	32.8
Mining/transportation	495	32.4
Mining/machine operators	91	28.5
Total for industry/occupations	62,604	4.6

Table IV provides a description of the injury external causes ordered by frequency. Machinery, electric current, homicide, fall, and transportation-related external causes occurred with high frequency. Age-related death rates in the

TABLE IV. Top 10 Injury External Causes (E-Codes) Ordered by Frequency for Occupational Fatal Injuries Occurring in Years 1983−1994

E-code	Injury description	Deaths	Rate per 100,000
919	Machinery accident	8,815	0.647
965	Homicide with firearms and explosives	7,318	0.537
812	Motor vehicle collision with other motor vehicle	4,792	0.352
916	Struck accidentally by falling object	4,395	0.322
925	Accident caused by electric current	4,372	0.321
816	Motor vehicle loss of control no collision	3,487	0.256
841	Powered aircraft accident unspecified	2,645	0.194
814	Motor vehicle collision with pedestrian	2,188	0.161
882	Fall from building or other structure	1,987	0.146
881	Fall from ladder or scaffolding	1,537	0.113
	Total deaths	68,892	5.055

a

b
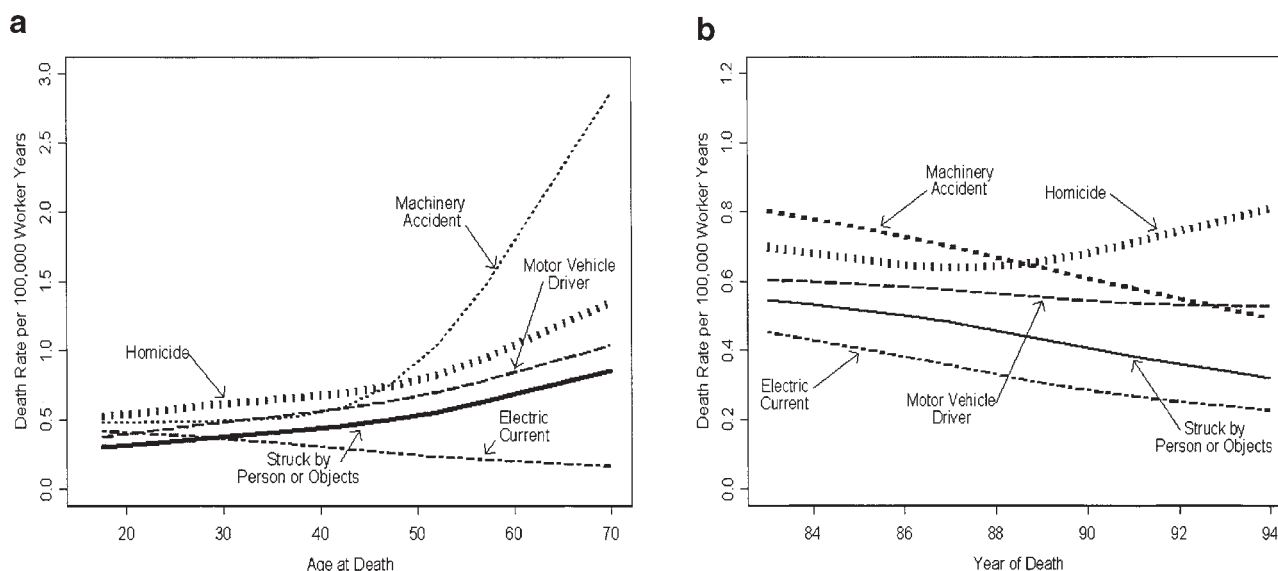
FIGURE 1. **a**: Age-specific death rates (per 100,000 worker years) for the top five external causes (as determined by frequency of occurrence) for occupational fatal injuries occurring in years 1983–1994. **b**: Death rates (per 100,000 worker years) versus calendar year for the top five external causes (as determined by frequency of occurrence) for occupational fatal injuries occurring in years 1983–1994.

most frequent external cause groups can be evaluated from Figure 1a. Only electrocution exhibited a decline in death rates with age at death. Machinery accidents exhibited an almost six-fold increase in death rates from age 20 to age 70. In contrast, age-specific homicide death rates increased by a factor of approximately 2.5 from age 20 to age 70. Similar increases with age were observed for motor-vehicle-driver and struck-by-person-or-object events. Calendar trends in death rates for the five most frequent external cause groups can be evaluated from Figure 1b. With the exception of homicide, the external cause groups exhibited a decrease in death rates from 1983–1994 although the motor vehicle driver event group trend was fairly flat.

Table V provides a description of the injury external causes ordered by frequency within industry while Table VI provides the same information within occupation. Machinery events (919) were associated with the highest fatal injury rate in agriculture, forestry and fishing (over 6 per 100,000), mining (over 6 per 100,000) and manufacturing (0.7 per 100,000). Struck by falling object (916) and electric events (925) were the next most frequent fatal events in these three industries.[1] Electric events and machinery were also common causes of fatalities in construction as were falls (882, 881, 884, and 888). Not surprisingly, fatal injury events in the transportation/communications/public utilities industries were dominated by motor vehicle-related events (812, 816,

841, 815, 819, and 814) although homicide (965), electric current (925), and machinery events (919) were also observed with relatively high frequency. Intentional injury and transportation-related events tended to be more prominent in wholesale trade, retail trade, finance, insurance and real estate, services and public administration. The top five external cause groups are displayed in Figure 2a where we graph the percentage of fatal injuries of a particular external cause contributed by each industry. From this figure, we see that over 40% of homicides occurred in the retail trade industry, 40% of motor vehicle driver fatalities occurred in the transportation industry, and 40% of the electric current fatalities occurred in the construction industry. Manufacturing industry accounted for over 30% of the struck-by-person-or-object fatalities. Manufacturing and construction each accounted for approximately 20% of the machinery accidents. Services and public administration industries also each accounted for over 10% of homicides.

In Table VI, the events associated with high fatal injury rates in executives, administration and managers tended to be predominantly homicide and transportation-related. For technical support occupations, over half of the fatal injuries occurred with the external cause "powered aircraft accident unspecified" (841). Homicide with firearms and explosives (965) contributed over one-third of the fatal injuries in sales, over one-fifth of the clerical fatal injuries, and over one quarter of the service fatal injuries. Machinery accidents (919), struck accidentally by falling object (916), and "accident caused by electric current" (925) accounted for over half of fatal injuries in farmers, foresters and fishers, and

[1]   The three digit number(s) that follow the description of an external cause corresponds to the E-code(s) associated with that external cause.

TABLE V. Top 10 Injury External Causes (E-Codes) Within Industry Ordered by Frequency for Occupational Fatal Injuries Occurring in Years 1983−1994

Industry	E-Code	Injury description	Deaths	Rate per 100,000
Agriculture, forestry and fishing	919	Machinery accident	2,571	6.3
	916	Struck accidentally by falling object	532	1.3
	925	Accident caused by electric current	447	1.1
	812	Motor vehicle collision with other motor vehicle	322	0.8
	816	Motor vehicle loss of control no collision	320	0.8
	910	Accidental drowning or submersion	245	0.6
	830	Accident to watercraft causing submersion	240	0.6
	832	Other drowning in watercraft accident	216	0.5
	884	Other fall from one level to another	212	0.5
	906	Other injury caused by an animal	171	0.4
	841	Powered aircraft accident unspecified	171	0.4
		Total for industry	7,834	19.3
Mining	919	Machinery accident	570	6.0
	916	Struck accidentally by falling object	344	3.6
	925	Accident caused by electric current	170	1.8
	923	Accident caused by explosive material	161	1.7
	812	Motor vehicle collision with other motor vehicle	117	1.2
	816	Motor vehicle loss of control no collision	103	1.1
	928	Unspecified environmental accident	87	0.9
	917	Struck accidentally by objects or persons	64	0.7
	913	Accidental mechanical suffocation	62	0.7
	846	Unspecified accident with powered vehicle	51	0.5
		Total for industry	2,476	26.1
Construction	925	Accident caused by electric current	1,736	2.0
	919	Machinery accident	1,630	1.9
	882	Fall from building or other structure	1,272	1.5
	881	Fall from ladder or scaffolding	927	1.1
	916	Struck accidentally by falling object	908	1.0
	814	Motor vehicle collision with pedestrian	660	0.8
	884	Other fall from one level to another	499	0.6
	913	Accidental mechanical suffocation	461	0.5
	812	Motor vehicle collision with other motor vehicle	406	0.5
	888	Other and unspecified fall	398	0.5
		Total for industry	12,408	14.3
Manufacturing	919	Machinery accident	1,848	0.7
	916	Struck accidentally by falling object	1,451	0.6
	925	Accident caused by electric current	526	0.2
	812	Motor vehicle collision with other motor vehicle	447	0.2
	965	Homicide with firearms and explosives	431	0.2
	923	Accident caused by explosive material	405	0.2
	917	Struck accidentally by objects or persons	308	0.1
	816	Motor vehicle loss of control no collision	274	0.1
	928	Unspecified environmental accident	254	0.1
	888	Other and unspecified fall	189	0.1
		Total for industry	9,472	3.8
Transportation, communication and public utilities	812	Motor vehicle collision with other motor vehicle	1,595	1.7
	816	Motor vehicle loss of control no collision	1,548	1.6
	841	Powered aircraft accident unspecified	865	0.9

TABLE V. (*Continued*)

Industry	E-Code	Injury description	Deaths	Rate per 100,000
	965	Homicide with firearms and explosives	777	0.8
	815	Motor vehicle collision on highway	685	0.7
	925	Accident caused by electric current	662	0.7
	919	Machinery accident	602	0.6
	819	Unspecified motor vehicle accident	570	0.6
	814	Motor vehicle collision with pedestrian	513	0.5
	916	Struck accidentally by falling object	358	0.4
		Total for industry	11,830	12.4
Wholesale trade	812	Motor vehicle collision with other motor vehicle	232	0.4
	919	Machinery accident	210	0.4
	816	Motor vehicle loss of control no collision	165	0.3
	965	Homicide with firearms and explosives	105	0.2
	916	Struck accidentally by falling object	79	0.1
	925	Accident caused by electric current	71	0.1
	815	Motor vehicle collision on highway	60	0.1
	955	Suicide/self-injury by firearms or explosives	54	0.1
	819	Unspecified motor vehicle accident	52	0.1
	923	Accident caused by explosive material	45	0.1
	913	Accidental mechanical suffocation	45	0.1
		Total for industry	1,673	3.1
Retail trade	965	Homicide with firearms and explosives	2,847	1.2
	966	Homicide with cutting and piercing object	397	0.2
	812	Motor vehicle collision with other motor vehicle	311	0.1
	955	Suicide/self-injury by firearms or explosives	294	0.1
	968	Unspecified and other homicide	251	0.1
	919	Machinery accident	193	0.1
	816	Motor vehicle loss of control no collision	147	0.1
	916	Struck accidentally by falling object	112	<0.1
	925	Accident caused by electric current	95	<0.1
	815	Motor vehicle collision on highway	91	<0.1
		Total for industry	6,048	2.6
Finance, insurance and real estate	965	Homicide with firearms and explosives	229	0.3
	812	Motor vehicle collision with other motor vehicle	111	0.1
	955	Suicide/self-injury by firearms or explosives	71	0.1
	919	Machinery accident	63	0.1
	841	Powered aircraft accident unspecified	43	<0.1
	816	Motor vehicle loss of control no collision	34	<0.1
	966	Homicide with cutting and piercing object	32	<0.1
	888	Other and unspecified fall	26	<0.1
	819	Unspecified motor vehicle accident	25	<0.1
	925	Accident caused by electric current	24	<0.1
		Total for industry	963	1.1
Services	965	Homicide with firearms and explosives	1,252	0.3
	812	Motor vehicle collision with other motor vehicle	523	0.1
	919	Machinery accident	451	0.1
	955	Suicide/self-injury by firearms or explosives	324	0.1
	841	Powered aircraft accident unspecified	316	0.1
	916	Struck accidentally by falling object	315	0.1

(*Continued*)

TABLE V. (*Continued*)

Industry	E-Code	Injury description	Deaths	Rate per 100,000
	925	Accident caused by electric current	307	0.1
	814	Motor vehicle collision with pedestrian	235	0.1
	966	Homicide with cutting and piercing object	204	<0.1
	816	Motor vehicle loss of control no collision	197	<0.1
		Total for industry	7,255	1.6
Public administration	841	Powered aircraft accident unspecified	839	1.3
	965	Homicide with firearms and explosives	756	1.2
	812	Motor vehicle collision with other motor vehicle	451	0.7
	814	Motor vehicle collision with pedestrian	264	0.4
	816	Motor vehicle loss of control no collision	235	0.4
	955	Suicide/self-injury by firearms or explosives	211	0.3
	919	Machinery accident	162	0.3
	815	Motor vehicle collision on highway	119	0.2
	922	Accident caused by firearm missile	93	0.1
	819	Unspecified motor vehicle accident	91	0.1
		Total for industry	4,854	7.6

in over 1/3 of crafts workers. Falls (882, 881, and 888) accounted for another 1/6 of fatal injuries among crafts workers. About 1/5 of the fatal injuries in machine operators, assemblers and inspectors were machinery accidents (919) with falling objects (916), explosive material (923) and electric current (925) events also representing a significant fraction of fatal injuries. Not surprisingly, approximately 50% of the transportation worker fatal injuries were motor vehicle-related events (816, 812, 815, 819, 814, and 810). Machinery (919) and homicide (965) were also common in this occupation. Fatal injury events in laborers included machinery (919), struck by falling objects (916), falls (882, 881, and 888), motor vehicles (814 collision with pedestrian and 812), and homicides (965). The top five external cause groups by occupation are graphically displayed in Figure 2b. We see that almost 30% of homicides occurred in the sales occupation and 20% occurred in the service occupations. About 50% of electric current fatalities occurred in crafts occupations and over 50% of motor vehicle driver fatalities occurred in the transportation occupation. Farming/forestry/ fishing and crafts occupations each accounted for over 25% of the struck by person or objects.

To illustrate a finer level of analysis, we explored age-specific death rates for machinery death by industry in Figure 3, age-specific death rates for electrocution deaths by occupation in Figure 4a, and age-specific death rates for all falls and two different types of falls in Figure 4b. Machinery death rates increased by approximately a factor of two in construction, transportation and manufacturing from age 20 to age 70. In contrast, an approximate eight-fold increase in machinery death rates was observed for agriculture, forestry and fishing. Interestingly, mining death rates exhibit-ed a non-monotonic pattern where rates initially decrease until approximately age 45 and then increase through age 70. Electrocution death rates decreased with age in crafts, farming, fishing and forestry, and transportation occupations (Figure 4a). The age-specific electrocution death rate was relatively constant for executives, administration and managers. In laborers, age-specific electrocution deaths tended to increase slightly through age 30 and then decrease through age 70. Finally, it is interesting to note the increase in age-specific death rates for falls from age 20 to age 70 (Figure 4b). An analysis of cause-specific fall death rates shows an interesting pattern in which the age-specific fatal injury rates from falls from ladders increased rapidly from age 20 to age 70, while rates from falls from buildings occurred at almost twice the rate of falls from ladders for the youngest workers and at almost half the rate for the oldest workers. Further, the death rate from falls from buildings increased through age 30 and then decreased slightly before increasing again from approximately age 40.

DISCUSSION

Counts or rates of fatal injury resulting from occupational hazards provide a sense of the magnitude of these events and their impact on public health. The patterns that we see in this analysis are consistent with other analyses based upon NTOF, the BLS data sets (CFOI/ASOII), and other sources. For example, the industries highlighted as having the largest total number of deaths in our analysis of the 1983–1994 NTOF data (see Table I), construction and transportation/public utilities, were also highlighted in the analysis of 1993 CFOI data [Toscano and Windau, 1994]. Stout et al.,

TABLE VI. Top 10 Injury External Causes (E-Codes) Within Occupation Ordered by Frequency for Occupational Fatal Injuries Occurring in Years 1983–1994

Occupation	E-code	Injury description	Deaths	Rate per 100,000
Executives, administration and managers	965	Homicide with firearms and explosives	997	0.6
	919	Machinery accident	397	0.2
	812	Motor vehicle collision with other motor vehicle	339	0.2
	955	Suicide/self-injury by firearms or explosives	260	0.2
	841	Powered aircraft accident unspecified	244	0.1
	925	Accident caused by electric current	242	0.1
	916	Struck accidentally by falling object	198	0.1
	966	Homicide with cutting and piercing object	159	0.1
	816	Motor vehicle loss of control no collision	121	0.1
	882	Fall from building or other structure	121	0.1
		Total for occupation	4,806	2.9
Professional specialty	841	Powered aircraft accident unspecified	299	0.2
	965	Homicide with firearms and explosives	298	0.2
	812	Motor vehicle collision with other motor vehicle	231	0.1
	919	Machinery accident	160	0.1
	955	Suicide/self-injury by firearms or explosives	119	0.1
	816	Motor vehicle loss of control no collision	87	<0.1
	814	Motor vehicle collision with pedestrian	79	<0.1
	925	Accident caused by electric current	75	<0.1
	910	Accidental drowning or submersion	73	<0.1
	888	Other and unspecified fall	65	<0.1
		Total for occupation	2,661	1.5
Technical support	841	Powered aircraft accident unspecified	956	2.2
	840	Aircraft accident during takeoff or landing	104	0.2
	812	Motor vehicle collision with other motor vehicle	82	0.2
	925	Accident caused by electric current	66	0.2
	814	Motor vehicle collision with pedestrian	65	0.2
	919	Machinery accident	60	0.1
	965	Homicide with firearms and explosives	44	0.1
	923	Accident caused by explosive material	40	0.1
	816	Motor vehicle loss of control no collision	30	0.1
	916	Struck accidentally by falling object	26	0.1
		Total for occupation	1,816	4.2
Sales	965	Homicide with firearms and explosives	1,826	1.1
	812	Motor vehicle collision with other motor vehicle	403	0.2
	955	Suicide/self-injury by firearms or explosives	278	0.2
	966	Homicide with cutting and piercing object	238	0.1
	968	Unspecified and other homicide	158	0.1
	919	Machinery accident	153	0.1
	816	Motor vehicle loss of control no collision	129	0.1
	841	Powered aircraft accident unspecified	94	0.1
	815	Motor vehicle collision on highway	84	0.1
	916	Struck accidentally by falling object	71	<0.1
		Total for occupation	4,410	2.7
Clerical	965	Homicide with firearms and explosives	278	0.1
	812	Motor vehicle collision with other motor vehicle	179	0.1
	919	Machinery accident	95	<0.1
	816	Motor vehicle loss of control no collision	61	<0.1

TABLE VI. (*Continued*)

Occupation	E-code	Injury description	Deaths	Rate per 100,000
	814	Motor vehicle collision with pedestrian	50	<0.1
	966	Homicide with cutting and piercing object	42	<0.1
	888	Other and unspecified fall	41	<0.1
	955	Suicide/self-injury by firearms or explosives	41	<0.1
	968	Unspecified and other homicide	40	<0.1
	916	Struck accidentally by falling object	29	<0.1
	815	Motor vehicle collision on highway	29	<0.1
	819	Unspecified motor vehicle accident	28	<0.1
		Total for occupation	1,313	0.6
Service	965	Homicide with firearms and explosives	1,341	0.7
	812	Motor vehicle collision with other motor vehicle	374	0.2
	814	Motor vehicle collision with pedestrian	217	0.1
	919	Machinery accident	210	0.1
	955	Suicide/self-injury by firearms or explosives	184	0.1
	966	Homicide with cutting and piercing object	152	0.1
	925	Accident caused by electric current	143	0.1
	968	Unspecified and other homicide	142	0.1
	816	Motor vehicle loss of control no collision	133	0.1
	841	Powered aircraft accident unspecified	129	0.1
		Total for occupation	4,834	2.6
Farmers, forestry and fishing	919	Machinery accident	2,681	6.4
	916	Struck accidentally by falling object	1,304	3.1
	925	Accident caused by electric current	399	1.0
	812	Motor vehicle collision with other motor vehicle	269	0.6
	816	Motor vehicle loss of control no collision	268	0.6
	910	Accidental drowning or submersion	230	0.6
	830	Accident to watercraft causing submersion	217	0.5
	884	Other fall from one level to another	216	0.5
	832	Other drowning in watercraft accident	205	0.5
	906	Other injury caused by an animal	179	0.4
		Total for occupation	8,457	20.2
Crafts	925	Accident caused by electric current	2,053	1.3
	919	Machinery accident	1,593	1.0
	916	Struck accidentally by falling object	1,067	0.7
	882	Fall from building or other structure	1,026	0.6
	881	Fall from ladder or scaffolding	804	0.5
	965	Homicide with firearms and explosives	502	0.3
	884	Other fall from one level to another	472	0.3
	812	Motor vehicle collision with other motor vehicle	466	0.3
	923	Accident caused by explosive material	406	0.3
	888	Other and unspecified fall	359	0.2
		Total for occupation	13,128	8.2
Machine operators, assemblers and inspectors	919	Machinery accident	551	0.6
	916	Struck accidentally by falling object	233	0.2
	923	Accident caused by explosive material	186	0.2
	925	Accident caused by electric current	168	0.2
	965	Homicide with firearms and explosives	126	0.1
	882	Fall from building or other structure	95	0.1

(*Continued*)

TABLE VI. (*Continued*)

| Occupation	E-code	Injury description	Deaths	Rate per 100,000
	917	Struck accidentally by objects or persons	87	0.1
	812	Motor vehicle collision with other motor vehicle	82	0.1
	928	Unspecified environmental accident	79	0.1
	891	Conflagration in unspecified building	67	0.1
	884	Other fall from one level to another	67	0.1
		Total for occupation	2,735	2.9
Transportation	816	Motor vehicle loss of control no collision	1,971	3.5
	812	Motor vehicle collision with other motor vehicle	1,852	3.3
	919	Machinery accident	1,350	2.4
	815	Motor vehicle collision on highway	809	1.4
	965	Homicide with firearms and explosives	715	1.3
	819	Unspecified motor vehicle accident	679	1.2
	814	Motor vehicle collision with pedestrian	539	0.9
	916	Struck accidentally by falling object	507	0.9
	925	Accident caused by electric current	346	0.6
	810	Motor vehicle collision with train	247	0.4
		Total for occupation	12,294	21.6
Laborers	919	Machinery accident	1,160	2.1
	916	Struck accidentally by falling object	669	1.2
	925	Accident caused by electric current	610	1.1
	965	Homicide with firearms and explosives	601	1.1
	814	Motor vehicle collision with pedestrian	489	0.9
	882	Fall from building or other structure	351	0.6
	913	Accidental mechanical suffocation	330	0.6
	881	Fall from ladder or scaffolding	252	0.5
	812	Motor vehicle collision with other motor vehicle	211	0.4
	888	Other and unspecified fall	188	0.3
		Total for occupation	7,662	13.7

[1996] examined industries using NTOF data over 1980–1989. Their analysis reported mining as having the highest fatal injury rate although, unlike this study, they found that construction and transportation/public utilities had higher rates than agriculture/forestry/fishing. The rates and ordering of occupations in Table II were very similar to that reported by Toscano and Windau [1994].

The pattern of age-related declines in electrocution death rates highlighted in Fig. 1a has also been reported overall by Myers and Hard [1999], in construction workers by Ore and Casini [1996], in agriculture production and services by Myers and Hard [1995], in electric utility workers in California by Kelsh and Sahl [1996] and in U.S. electric power workers by Loomis et al. [1999]. An increase with age in fatal injury rates due to machinery (Fig. 1a) was previously reported by Pratt et al. [1996].

The specific analyses of external causes in Tables V and VI are similar to analyses reported by Stout et al. [1996] and Toscano and Windau [1994]. Toscano and Windau [1994] reported the percentage of time a particular external cause (event or exposure group in their tables) occurred in a particular industry or occupation while we considered the percentage of a particular industry/occupation in an external cause (Fig. 2a and 2b).

The difference in the nature of fall-related fatalities between younger and older workers was previously discussed by Windau et al. [1999]. They noted that young workers experienced fatalities from falls though a skylight or roof while adult construction workers were more likely to fall from scaffolding, building girders, and ladders. Kisner and Pratt [1997] also noted age-related differences in the types of falls when comparing workers age 65 + years versus age 16–64 years. Agnew and Suruda [1993] also studied fatal injury resulting from falls as a function of age. They reported that annual fatal injury rates associated with falls increased as a function of age (from 0.7/100,000 for 16–19 year old

a

b
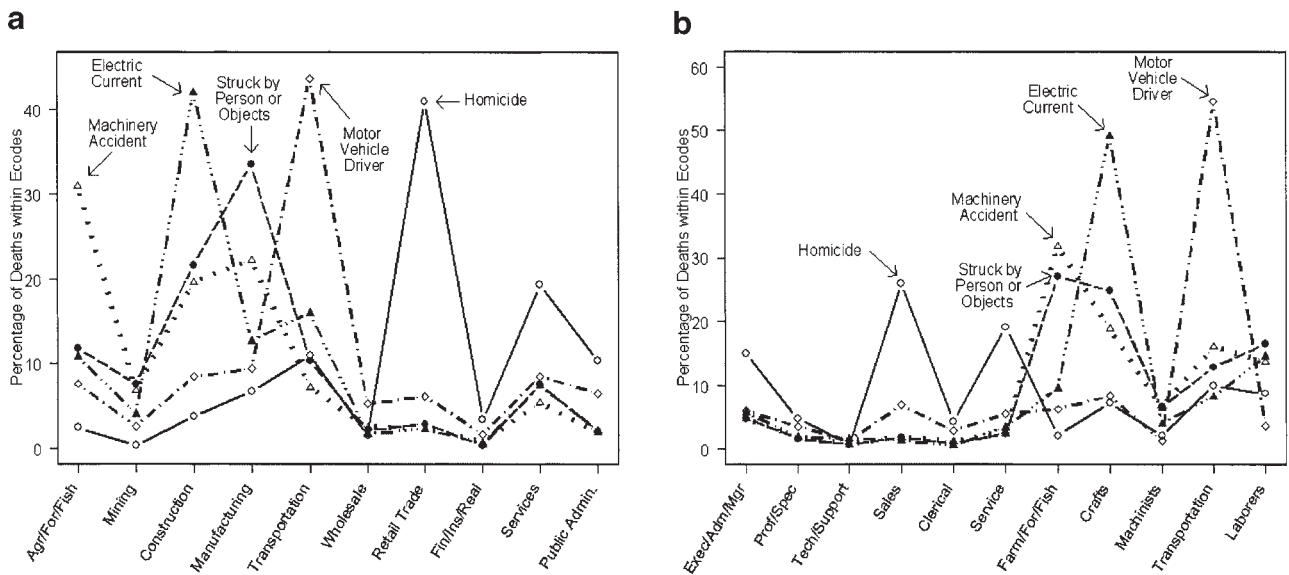
FIGURE 2. **a**: Percentages of occupational fatal injuries within each of the top five external causes across industries in years 1983–1994. Points are connected to provide a visual reference for tracking external causes across industries. **b**: Percentages of occupational fatal injuries within each of the top five external causes across occupations in years 1983–1994. Points are connected to provide a visual reference for tracking external causes across occupations.

workers to 3.0/100,000 for 65 + year old workers). In addition, falls accounted for 7% of work-related injury deaths for 16–19 year old workers, and this percentage increased to 12% for 65 + year old workers. Similar age-specific patterns, as illustrated in Fig. 4b, were also observed

in the general population [cf. Fig. 10-1 in Baker et al., 1992]. Factors that might contribute to these patterns are discussed by both Agnew and Suruda [1993] and Baker et al. [1992]. In particular, age-related changes in motor performance, control of postural stability, reduced strength, and increased
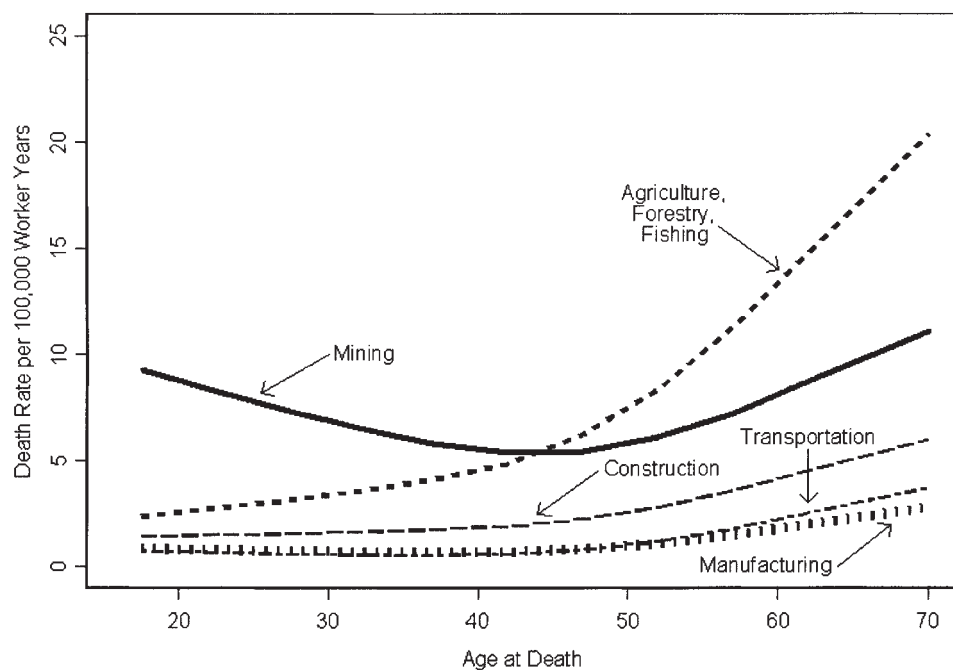
FIGURE 3. Age-specific death rates (per 100,000 worker years) for the top five industries in machinery deaths (as determined by frequency of occurrence) for occupational fatal injuries occurring in years 1983–1994.
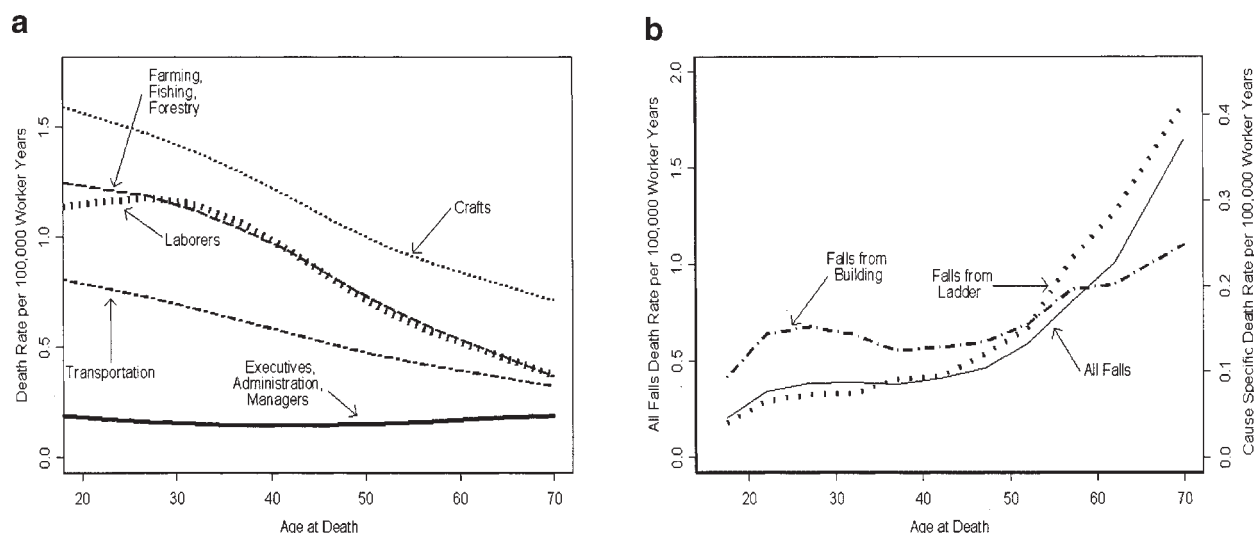
FIGURE 4. **a**: Age-specific death rates (per 100,000 worker years) for the top five occupations in electrocution deaths (as determined by frequency of occurrence) for occupational fatal injuries occurring in years 1983–1994. **b**: Age-specific death rates (per 100,000 worker years) for all falls (solid line) and separately for cause-specific falls ("from ladders" and "from buildings and heights") for occupational fatal injuries occurring in years 1983–1994.

vulnerability to injury are all mentioned as possible explanatory factors.

The impact of violence in the workplace has been noted in a variety of different sources including many of the general analyses previously cited [Toscano and Windau, 1994; Stout et al., 1996] and specific articles devoted to this topic [Toscano and Weber, 1995]. Peek-Asa et al. [1999] have noted this specific pattern in the retail industry in their discussion of violence in the workplace.

One limitation of these data is that while relatively fine distinctions are possible with external cause of death codes, only gross distinctions are possible within industries (10 levels) and occupations (11 levels). Thus, when a high rate is noted for a particular external cause of death in a certain industry, the specific sectors contributing the excess remain unknown as do the actual hazardous conditions or other factors responsible for the injuries. As an example, the fatal injury rate due to machinery accidents (919) in agriculture, forestry and fishing was 6.3 per 100,000. A natural follow up to this analysis would be to explore what specific types of agriculture, forestry or fishing enterprises experience the high fatal injury rates. In our analysis, machinery, electric current, homicide, fall and transportation-related events are highlighted by high frequencies or rates of occurrence in many categories of industry and occupation.

Limitations of the NTOF, including incomplete case ascertainment and potential misclassification of industry and occupation, have been described in other publications [e.g., NIOSH, 1993]. We acknowledge the possible limitation of using data that are 8 years old. This certainly suggests some caution be employed when making recommendations for

targeting interventions. Death certificates capture a fraction of all occupational fatal injuries. Stout and Bell [1991] reported that death certificates picked up 81% of all work-related deaths (average over 10 states; range 67–90%) while Russell and Conroy [1991] reported that death certificates captured 57–88% of occupational injury death in a 2-year period in Oklahoma. Despite this limitation, we are encouraged that analyses based upon NTOF are consistent with analyses based on other sources.

Because of the high frequency of deaths due to workplace homicide, falls, machinery-related, motor vehicle-related, and electric current causes, efforts should be intensified to identify the hazardous conditions responsible and implement interventions. An example might be targeted interventions for homicide in sales and service occupations along with retail trade and services industries. Similarly, younger workers might be targeted for special interventions designed to identify hazardous practices, procedures, and solutions to reduce fatalities associated with electrocution or falls from buildings.

ACKNOWLEDGMENTS

Appendix: Industry and Occupation Descriptions

Industry	Examples
Public administration	Justice, public order & safety, human resources administrative, environment quality and housing, economic programs
Transportation and public utilities	Railroad, cabs, trucking, water & air transport
Finance, insurance and real estate	Banks, brokers, insurance agents, real estate agents
Construction	General construction, heavy construction, special trade construction
Mining	Metal, coal, oil and gas, sand & gravel
Services	Hotels, auto repair, miscellaneous repair
Agriculture, forestry and fishing	Crops, livestock
Manufacturing	Food products, textile, lumber, furniture, stone, metal
Retail trade	Building materials, general merchandise, food stores, automobile dealers, apparel stores, furniture, eating/drinking places
Wholesale trade	Durable goods——vehicles, construction materials, machinery; non-durable goods——groceries, petroleum products
Occupation	
Technicians & related support	Health technicians, science technicians, airplane pilots
Handlers, helpers, laborers	Helpers——mechanics, construction, etc.; freight-stock-material handlers, service station occupations
Transportation material moving	Truck-bus-cab drivers, ship captains-mates-sailors, railroad, material movers——crane, grader, dozer, scraper
Executives, administrators & managers	Legislators, financial managers, accounts/auditors
Service occupations	Household——cooks, private child care; protective——police, fire, guards; other-food preparation, health aides, barbers
Professional specialty	Engineers, architects, surveyors, scientists, teachers, librarians, social scientists
Precision production, crafts & repair	Mechanics & repairers, HVAC, construction trades, tool & die makers, butchers/meat cutters
Clerical and administrative support	Supervisors, computer equipment operators, secretaries, tellers, postal clerks
Farming, forestry and fishing	Farm/nursery managers & workers, loggers & cutters, fishers, hunters & trappers
Sales occupations	Sales representatives, financial/business
Machine operators, assemblers, inspectors	Metalworking, fabricating machine operators, woodworking operators, fabricators, production Inspectors

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