Pergamon

www.elsevier.com/locate/jsr

Journal of Safety Research 37 (2006) 307 – 319

www.nsc.org

Work-related deaths in Washington State, 1998–2002

Martin A. Cohen [a], Randy E. Clark [b,*], Barbara Silverstein [b], Tom Sjostrom [b], Peregrin Spielholz [b]

[a] *Department of Environmental and Occupational Health Sciences, University of Washington, 4225 Roosevelt Way NE, Suite 302, Seattle, WA 98105, USA*
[b] *Washington State Department of Labor and Industries, Safety and Health Assessment and Research for Prevention (SHARP) Program, PO Box 44330, Olympia, WA 98504–4330, USA*

Received 14 November 2005; accepted 27 February 2006
Available online 11 July 2006

Abstract

Introduction: In Washington State, 87 workers are killed each year, on average, while in work status. To understand these incidents and to assist in focusing on and development of potential prevention measures, they must be well characterized. *Methods:* Work-related fatalities between the years 1998 and 2002 are described by the demographics of the victims, types of incidents, the victims' occupations, and industries and location in which they worked. *Results:* Motor vehicle- and machinery-related incidents accounted for nearly 33% and 14% of the incidents, respectively. Agriculture, forestry, fishing, hunting, and mining (n=87), and construction (n=83) had the most fatalities. Fatality rates per 100,000 workers for these industries were 25.7 and 8.7, respectively, compared to the state-wide average of 3.1 fatalities/100,000 workers. *Discussion:* These data indicate numerous areas for prevention of work-related traumatic injuries and fatalities.

Keywords: Work-related fatalities; Injury surveillance system; Injury prevention; Washington State

1. Introduction

In 2002, an average of 15 U.S. workers died each day due to traumatic injuries related to their work (United States Bureau of Labor Statistics [USBLS], 2003a). For the same year in Washington State, on average, one worker died every 5 days (Washington State Census of Fatal Occupational Injuries [WA CFOI], 2003). When these values are compared to the 215 logging fatalities in Washington in 1923 (Prouty, 1985), the situation seems greatly improved, but most if not all of the work-related deaths in 2002 could have been prevented.

Nationwide, in 2002, 5,524 workers died from work–related injuries (USBLS, 2003a). Twenty percent of those workers were in construction, 16% in transportation and public utilities, and 14% in agriculture, forestry and fishing. Forty-three percent of the deaths were due to transportation incidents, 16% due to contact with objects or equipment, and 15% due to assaults and violent acts. Truck drivers, farming and sales occupations, and construction laborers accounted for 35% of these fatalities. Each industry, incident type, and occupation had different situations leading up to the incidents. The better we understand the specifics and generalities, the better we can prevent future incidents from occurring.

A number of studies have looked more closely at fatality patterns in some of these industries and occupations. Different incident types and hazards have also been studied in a variety of countries and regions in the United States. Fatalities in logging (Paulozzi, 1987; Marshall et al., 1994), construction (Buskin & Paulozzi, 1987; Pollack, Griffin, Ringen, & Weeks, 1996), fishing (Thomas, Lincoln, Husberg, & Conway, 2001), agriculture (Conroy & Sciortino, 1997; Myers & Hard, 1995), electric utilities (Loomis,

* Corresponding author. Tel.: +1 360 902 5661; fax: +1 360 902 5672.
E-mail address: claa235@lni.wa.gov (R.E. Clark).

0022-4375/$ - see front matter
doi:10.1016/j.jsr.2006.02.007

Dufort, Kleckner, & Savitz, 1999), manufacturing, (Jeong, 1999), and retail (Peek-Asa, Erickson, & Kraus, 1999) are described in the literature.

Fatality rates have been found to vary greatly by industry and occupation in various locations. Table 1 summarizes the fatality rates for select industries and occupations. These rates vary from 430 deaths/100,000 workers for pilots in Alaska to 3 deaths/100,000 retail workers in the United States.

Victim demographics have been studied to help determine if various sub-populations have elevated risks and exposures to hazards. The three most commonly studied factors are age (young and old; Agnew & Suruda, 1993; Suruda, Philips, Lillquist, & Sesek, 2003; Windau, Sygnatur, & Toscano, 1999), sex (Ore, 1998; Jenkins, 1994), and race (Loomis & Richardson, 1998). It should be noted that these factors may not be causative or protective factors, but may be acting as surrogates for the types of jobs these individuals perform.

Surveillance for workplace fatalities has been conducted in the United States in select industry sectors since the early 1900s (National Research Council [NRC], 1987) and in Washington since 1912 (Prouty, 1985). The early surveillance systems did not cover all industry sectors or all workers. Currently in Washington, there are two surveillance systems for work-related fatalities, the WA Census of Fatal Occupational Injuries (CFOI) Program and the WA Fatality Assessment and Control Evaluation (FACE) Program. The CFOI Program has the objective of collecting comprehensive information on fatal occupational injuries (Austin, 1995). The WA FACE Program's goals are for the prevention of work-related fatalities through identification of these incidents and investigation into their root causes with direct dissemination of this information to affected industries and policy makers (Higgins, Casini, Bost, Johnson, & Rautiainen, 2001).

This article describes and characterizes the Washington State FACE Program's surveillance system, characterizes the fatalities in Washington between 1998 and 2002, and describes how the data have driven a number of prevention activities.

2. Methods

The surveillance system used by the WA FACE Program is multi-sourced and uses active and passive case ascertainment. The following describes the case definition for the FACE Program, major data sources, and how the data are processed and analyzed.

3. Case definition

A fatal incident is included by the system if the victim was working in Washington or in/on the waters of Washington and died due to a work-related acute trauma incident. The criteria for work-relatedness are derived from the Physician's Handbook on Medical Certification of Death (National Center for Health Statistics [NCHS], 2003). The incident types included are defined by the Internal Classification of Disease 9th revision (ICD9; NCHS, 1979) external causes of injury codes (e-codes), where the event is due to acute trauma (including self-inflicted, acute chemical exposures, and motor-vehicle collisions). Common types of fatal incidents that may occur at work, but are not included are deaths due to natural causes (e.g., heart attacks and aneurisms) unless there was a work-related underlying cause. Work-related diseases are also not included. An incident is counted in the year in which the incident occurred. A worker's industry is defined by the North American Industry Classification System 2002 (NAICS) codes (United States Census Bureau [USCB], 2004) and the occupation by the Census Occupation Codes (COC) (USCB, 1992).

4. Case reporting

Case reports and supplemental information on cases are derived from a number of different reporting sources. Fig. 1 outlines the reporting process for three important sources of incidents: WISHA (Washington State Industrial Safety and Health Act Program), workers' compensation claims, and death certificates. Cases derived from news reports are generally found directly by WA FACE staff.

Table 1
Fatality rates for select high risk industries and occupations

Location	Population	Fatality rate (deaths/100,000 workers)	Year (s)	Source
Alaska, U.S.	Pilots	430	1991–1998	Conway et al., 1999
New Zealand	Loggers	203	1975–1988	Marshall et al., 1994
Washington State, U.S.	Loggers	200	1977–1983	Paulozzi, 1987
Alaska, U.S.	Loggers	175	1991–1998	Conway et al., 1999
United States	Const.- Structural metal workers	153	1992	Pollack et al., 1996
Alaska, U.S.	Fishers	115	1991–1998	Conway et al., 1999
United States	Agricultural production	23	1980–1989	Myers & Hard, 1995
South Korea	Manufacturing	20	1991–1994	Jeong, 1999
United States	Construction-overall	14.2	1992	Pollack et al., 1996
United States	Agricultural services	13	1980–1989	Myers & Hard, 1995
United States	Const. - Carpenter apprentices	8.1	1992	Pollack et al., 1996
United States	Retail	3	1992–1996	Peek-Asa et al., 1999

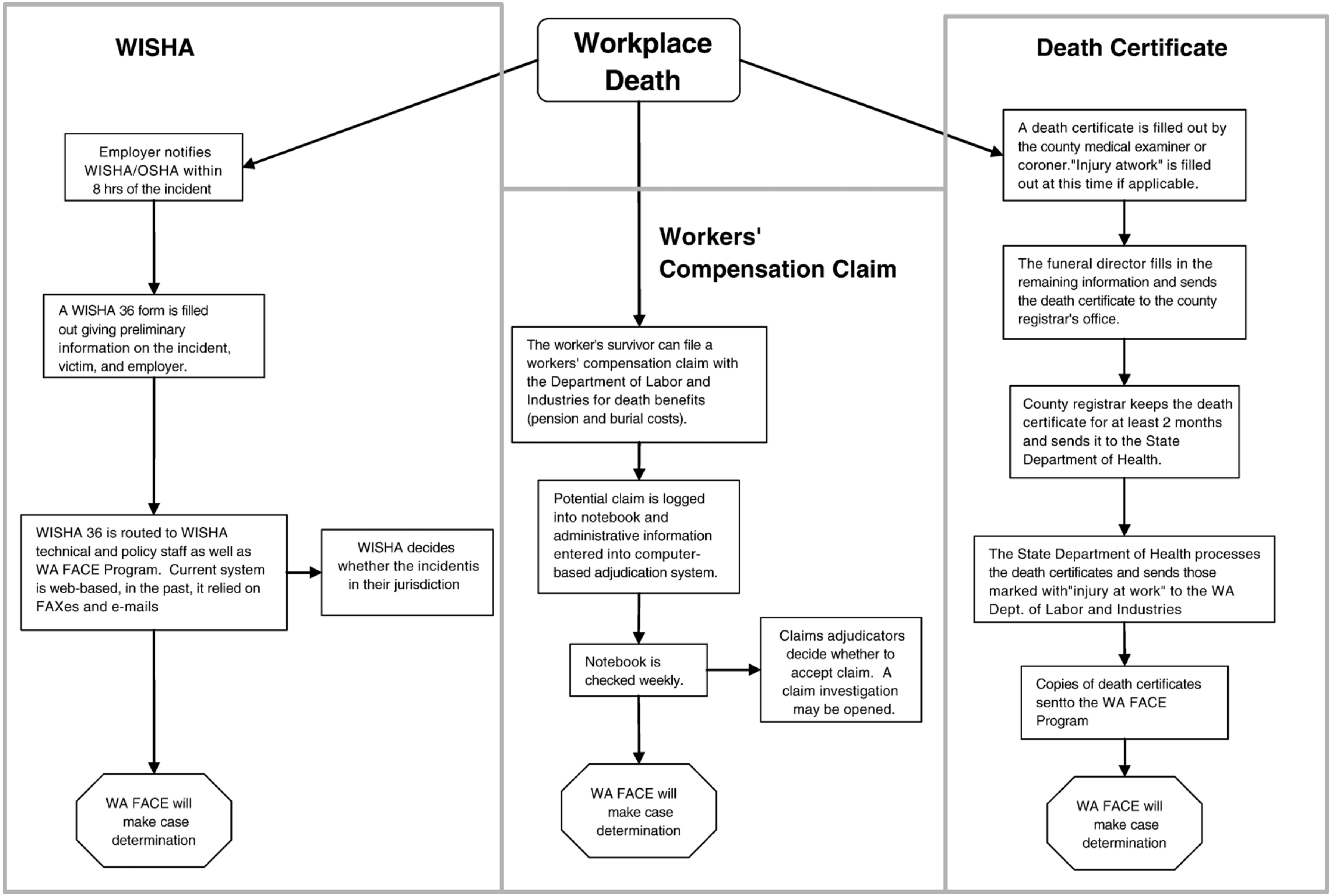

Fig. 1. Flow of information to the WA FACE surveillance system from major sources.

4.1. Employment data

Data for employment, which were used to calculate fatality rates, came from the U.S. Census Bureau's summary files 3 and 4 from the year 2000 decennial census (USCB, 2000). Data were downloaded from the Census Bureau's web site for the employed, non-institutionalized civilian population 16 years and older for Washington by industry sector (2 digit NAICS 1997 codes), by sex, race, ethnicity, and county of their workplace. For purposes of aggregation, the census included mining with agriculture, forestry, fishing, and hunting; utilities with transportation and warehousing; finance and insurance with real estate and rental and leasing; professional, scientific, and technical services with management of companies and enterprises as well as administrative and support of waste management services; educational services with health care and social assistance; and arts, entertainment, and recreation with accommodation and food services.

In calculating fatality rates we combine employment data using NAICS 1997 and fatality data coded with NAICS 2002. There were a number of changes in the coding system between 1997 and 2002, especially in the construction sector, that would make it difficult to calculate fatality rates at the NAICS 6 digit level. When the codes are aggregated to the 2-digit level, there are relatively few changes between the systems and none that affect our fatality data. Thus, fatality rates were only calculated at the NAICS 2-digit level.

To estimate the size of the working population in the years of no census, annual estimates of the working population in Washington for 1998 through 2002 were derived from the U.S. BLS' Current Population Survey (CPS; USBLS, 2003b). A ratio of Census to CPS populations was calculated for the year 2000. The CPS data were then multiplied by this ratio to calculate an estimate of the off-year census data, accounting for differences between the two systems and changes in the population over time.

5. Data entry and analysis

When a potential case is identified, a paper form is filled out with the information at hand and entered into a Microsoft Access (Microsoft, Redmond, WA) database. As more information is collected on an incident, it is entered into the database. Data are exported to SPSS version 11.5 (Statistical Package for Social Sciences, Chicago, IL) for summary and analysis. Upper and lower confidence limits were calculated for the rates using an assumption that the fatality counts were Poisson distributed. Standard errors for the employment levels were derived from the Census data's documentation (USCB, 2000) with an assumption that the standard error was the same for all five years. Fatality rates were reported as the number of fatalities per 100,000 employees.

6. Results

6.1. Data sources

Seventy-one percent of our incidents were identified in reports from news agencies (paper or internet-based newspapers, radio, and television) and the WISHA Program (Table 2). The prevalence of the different reporting sources has changed slightly from year to year. For incidents where the worker dies on the same day as the incident (82% of the deaths), the median number of days between the incident and the WA FACE Program being notified is 1.6 days. The average number of days for notification is 22, with 80% of the deaths having notifications within 6 days of the incident.

6.2. Demographics

In the 5-year period between 1998 and 2002, 437 workers had work-related fatal incidents in Washington, as recorded by the WA FACE Program. Victim demographics are outlined in Table 3. The "average" worker killed in Washington was a 42 year-old white, non-Hispanic male, though this differed greatly by industry sector. The range of victims' ages was between 15 and 91 years old.

6.3. Fatalities over time

Over time, the number of fatalities has generally been decreasing, with a slight rise in 2001 (Fig. 2). Because there are relatively few fatalities each year, one or two incidents with 2 or more victims can influence the trend. In the years 1998 and 2001, there were 10 and 4 multiple victim incidents, respectively. In 1998, there was one – 6 victim incident (refinery explosion), two – 3 victim incidents, and seven – 2 victim incidents. In 2001, there was one – 4 victim incident (wildfire firefighters caught in blaze), one – 3 victim incident, and two – 2 victim incidents.

The fatality rates started at 4.1 fatalities/100,000 worker in 1998, dropped to 2.5 in 2000, but rose and then dropped to 2.6 in 2002, which tracks the trend for the total number of fatalities each year.

6.4. E-codes

Nearly one-third of the work-related deaths in Washington were due to motor vehicle-related incidents (Table 4).

Table 2
Distribution of reports by reporting source

Reporting source	Number	Percent
Death certificate	33	8
News reports	155	36
WISHA	155	36
Workers compensation	75	17
Total	437	100

Table 3
Demographics of victims, total of 437 victims

Age	Mean and median age	42 years old
	#<18 years old	3 victims (<1%)
	#>65years old	23 victims (5%)
Ethnicity	Not Hispanic	85%
	Hispanic	12%
	Unknown	3%
Race	White	88%
	Black	3%
	Asian/Pacific Islander	3%
	American Indian	2%
	Unknown	4%
Gender	Male	92%

Machinery, falls, struck by falling objects, and homicide were responsible for 14%, 11%, 8%, and 7%, respectively. These 5 types of incidents account for 72% of the fatalities. For motor-vehicle incidents, 42 incidents were a result of the driver losing control and 31 from a collision. Nearly one-third of the machinery incidents were due to lifting equipment such as fork-lift trucks, cranes, and personnel lifts and one-third of the falls due to falls from a building.

6.5. Homicide

Homicide deaths were investigated further and the alleged perpetrator of the crime was deduced based on the best information available to us. Of the 29 homicides, approximately 80% of victims had alleged perpetrators of the crimes that were family members/acquaintances/co-worker or clients (Table 5). All of the homicides in the agriculture, forestry, fishing, and hunting sector were allegedly perpetrated by family members/acquaintances/co-worker, while all of those in public administration by clients, and in service by strangers. All of the homicide victims in public administration were white, non-Hispanic workers, while all of the homicide victims in agriculture, forestry, and fishing

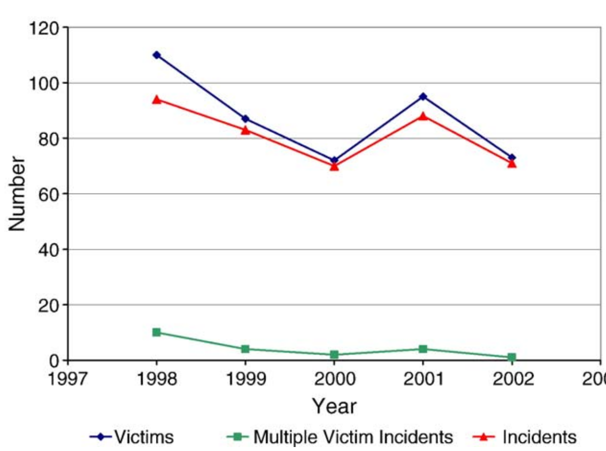

Fig. 2. Number of Victims, Multiple Victim Incidents, and Incidents per year.

Table 4
Distribution of fatalities by e-code

E-code	Frequency	Percent
Motor vehicle	141	32.3
Machinery	62	14.2
Fall	50	11.4
Struck by falling object	35	8.0
Homicide	29	6.6
Air transportation	18	4.1
Electrocution	16	3.7
Drowning	13	3.0
Suicide	13	3.0
Water transportation	12	2.7
Flying object/Caught in	10	2.3
Fire/Burn	9	2.1
Poisoning	9	2.1
Explosion	7	1.6
Other	13	3.0
Total	437	100

were either minorities (non-white or Hispanic) or had unknown races or ethnicities.

6.6. Occupation

The workers who died had a variety of occupations (Table 6), with truck drivers, construction laborers, and farm workers accounting for the most fatalities. Operators, fabricators, and laborers accounting for 37%; farming, forestry, and fishing accounting for 18%; and precision products, crafts, and repair occupations accounting for 18% of the deaths. By further categorizing the occupations, supervisors, managers, and executives accounted for 5% (n=21) and law enforcement officials 3% (n=13) of the fatalities. Of the 21 management worker deaths, 24% were homicide and 20% motor vehicle-related, while for the 13

Table 5
Distribution of homicide fatalities by relationship between victim and perpetrator by industry division for those with one or more homicide

Industry division	Client	Family member/ acquaintance/ co-worker	Stranger	Total
Accommodation and Food Services	0	0	1	1
Agriculture, Forestry, Fishing and Hunting	0	5	0	5
Arts, Entertainment, and Recreation	0	2	0	2
Construction	0	2	0	2
Educational Services	0	0	2	2
Manufacturing	0	1	0	1
Other Services (except Public Admin.)	0	0	1	1
Public Administration	6	0	0	6
Real Estate and Rental and Leasing	1	0	1	2
Retail Trade	2	1	1	4
Transportation and Warehousing	2	1	0	3
Total	11	12	6	29

Table 6
Occupations with 5 or more fatal incidents

Code	Occupation description	Number	Percent
804	Truck drivers, excluding Logging	71	16.2
869	Construction laborers	26	5.9
479	Farm workers	22	5.0
496	Timber cutting and logging occupations	16	3.7
22	Mangers and Administrators, nec	14	3.2
889	Laborers, excluding construction	14	3.2
498	Fishers	13	3.0
473	Farmers, except horticultural	12	2.7
243	Supervisors and Proprietors-Sales	7	1.6
418	Police/Detectives-public	7	1.6
486	Groundskeepers/Gardeners, excluding farmers	7	1.6
809	Taxi Drivers/Chauffeurs	7	1.6
558	Supervisors, Construction nec.	6	1.4
226	Airplane Pilots/Navigators	5	1.1
423	Sheriffs/Law enforcement	5	1.1
453	Janitors and Cleaners	5	1.1
567	Carpenters and Apprentices	5	1.1
579	Painters-Construction and maintenance	5	1.1
595	Roofers	5	1.1
783	Welders/Cutters	5	1.1
853	Excavation/Loading Machine Operators, Excluding Logging	5	1.1

nec.-not elsewhere classified.

law enforcement officers, 38% of the deaths were homicide and 23% motor vehicle-related.

6.7. Occupation by e-code

To better focus resources for prevention, the occupations are investigated by incident types (e-codes) in Fig. 3. Workers in many of the top 10 occupations are killed in manners consistent for those trades. Laborers fall from elevation and are killed by machinery; truck drivers die in motor vehicle collisions; fishers drown or die due to a vessel capsizing; logger are struck by trees, logs or branches; farmers and farm workers are killed by farm machinery; police officers are shot by alleged perpetrators; sales people are killed by others; and managers and administrators are killed in motor-vehicle collisions.

Table 7
Distribution of industries (NAICS codes), top 18

NAICS	NAICS Description	Number	Percent
113310	Logging	26	5.9
484121	General Freight Trucking, Long_Distance, Truckload	15	3.4
238910	Site Preparation Contractors	11	2.5
922120	Police Protection	11	2.5
237310	Highway, Street, and Bridge Construction	11	2.5
111998	All Other Miscellaneous Crop Farming	8	1.8
924120	Administration of Conservation Programs	8	1.8
928110	National Security	8	1.8
114111	Finfish Fishing	7	1.6
236220	Commercial and Institutional Building Construction	7	1.6
484110	General Freight Trucking, Local	7	1.6
111339	Other Non_citrus Fruit Farming	7	1.6
324110	Petroleum Refineries	6	1.4
238160	Roofing Contractors	6	1.4
561730	Landscaping Services	6	1.4
238320	Painting and Wall Covering Contractors	5	1.1
114112	Shellfish Fishing	5	1.1
321113	Sawmills	5	1.1

6.8. Industry

When the deaths are examined by the NAICS code sector in which the workers were employed, 19% of the fatalities

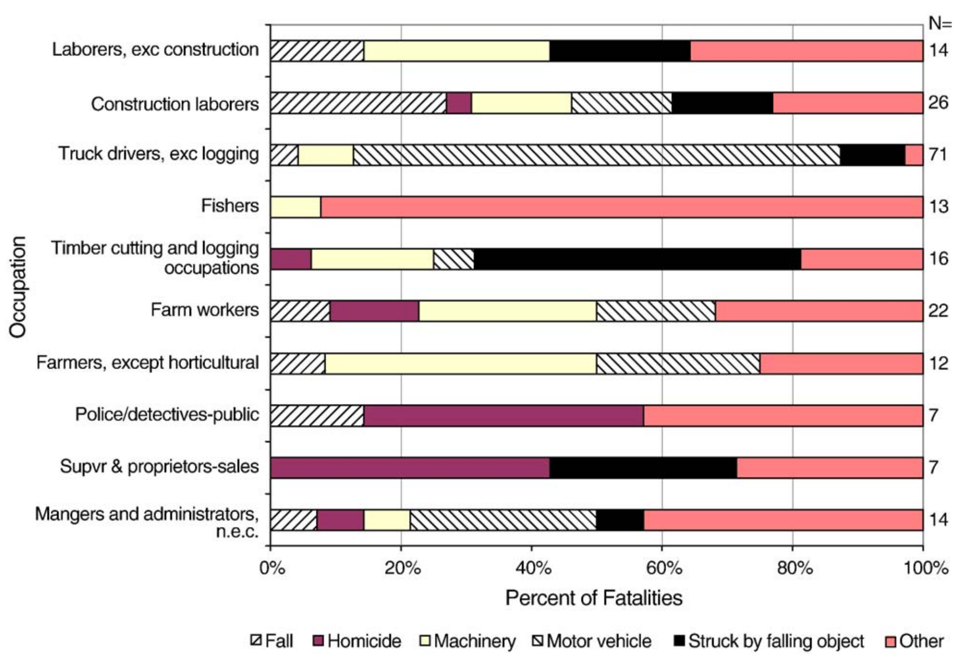

Fig. 3. Distribution of fatalities by occupation and e-code.

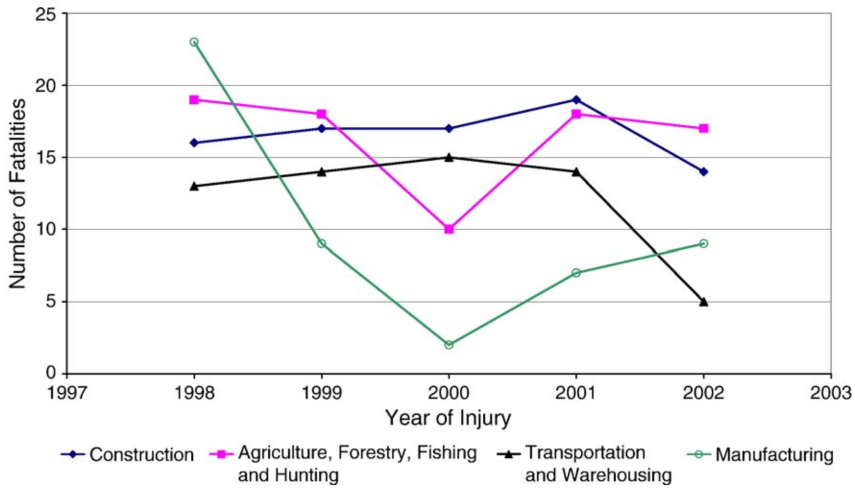

Fig. 4. Number of fatalities by industry division per year (4 divisions with the most fatalities).

were in construction, 19% in agriculture, forestry, fishing, and hunting, 14% in transportation and warehousing, and 11% in manufacturing. Construction special trades (n=47), crop production (n=29), forestry and logging (n=27), truck transportation (n=33), and transportation equipment manufacturing (n=11), accounted for most in their respective industry sectors. Table 7 shows the 18 industries with the most fatalities. Logging and long-distance general freight truckload trucking have the most fatalities in this time period.

Table 8
Fatality rates by industry and demographic groups, fatalities/100,000 worker, 1998–2002, for groups with >=10 fatalities in the time period, includes civilian, non-institutionalized workers ≥16 years of age

	Number of fatalities	Employees	Rate (deaths/100,000 employee)	95th% lower confidence limit	95th% Upper confidence limit	Rate ratio (95% LCL/95%UCL)
Industry *						
Ag., Forest., Fish. and Hunt. AND Mine	87	338,528	25.7	20.83	31.71	8.2 (6.51/10.32)
Transport. and Warehouse AND Util's.	66	741,020	8.9	7.00	11.34	2.8 (2.19/3.68)
Construction	83	956,408	8.7	7.00	10.76	2.8 (2.19/3.50)
Public Administration	33	691,720	4.8	3.39	6.71	1.5 (1.07/2.17)
Wholesale Trade	19	557,175	3.4	2.18	5.35	1.1 (0.69/1.72)
Manufacturing	50	1,711,121	2.9	2.21	3.86	0.9 (0.70/1.25)
Prof., Scientific, and Tech. Scvs. AND Admin. and Support	22	1,337,237	1.6	1.08	2.50	0.5 (0.34/0.81)
Retail Trade	26	1,662,660	1.6	1.06	2.30	0.5 (0.34/0.74)
Ed. Services AND Health Care and Soc. Assist	16	2,656,226	0.6	0.37	0.98	0.2 (0.12/0.32)
State-wide	430	13,711,319	3.1	2.85	3.45	1.0
Sex						
Male-Overall	396	7,360,035	5.38	4.88	5.94	10.05 (7.08/14.27)
Female-Overall	34	6,351,284	0.54	0.38	0.75	1.00
Ethnicity						
Hispanic-Construction	11	57,094	19.27	10.66	34.82	2.51 (1.33/4.74)
Non-Hispanic-Construction	69	899,315	7.67	6.06	9.71	1.00
Hispanic-Ag, Forest, Fish	23	114,673	20.06	13.32	30.20	0.72 (0.45/1.17)
Non-Hispanic-Ag, Forest, Fish	62	223,854	27.70	21.59	35.53	1.00
Hispanic-Overall	54	814,933	6.63	5.07	8.65	2.35 (1.76/3.12)
Non-Hispanic-Overall	364	12,896,386	2.82	2.55	3.13	1.00
Race						
Black	12	375,037	3.20	1.82	5.63	0.97 (0.55/1.73)
Asian/Pacific Islander	12	871,403	1.38	0.78	2.42	0.42 (0.24/0.74)
White	380	11,544,916	3.29	2.98	3.64	1.00

* All entries with an "AND" in all capital letters signifies that the industry sectors were aggregated further than the original NAICS industry sector designations.

Industry sector trends over time are plotted in Fig. 4 for the four sectors with the most fatalities. The manufacturing industry sector has quite variable numbers of fatalities over time, which is partly driven by a number of multiple victim incidents. Construction and agriculture, forestry, fishing, and hunting have been relatively constant over time.

When the industries are examined by their fatality rates (Table 8), agriculture, forestry, fishing, hunting, and mining (AFFHM), transportation, warehousing and public utilities (TWPU), construction, and public administration all have rates that are greater than the state-wide average of 3.10 fatality/100,000 worker ($p<0.05$). In AFFHM, the primary industries with fatalities are logging, miscellaneous crop farming, fin fishing, and non-citrus fruit farming. In TWPU, the industries elevating the rate are long-distance truckload trucking and local trucking. In construction, site preparation and highway, street, and bridge construction firms accounted for 26% of the deaths and a number of different specialty trades accounted for another 10% of deaths. In public administration, police protection, administration of conservation programs, and national security, accounted for 71% of the deaths in this industry sector.

Rates were investigated by demographic factors and by select industries (Table 8). No statistically significant differences ($p>0.05$) were found between white and black workers, but Asian/Pacific Islanders had a significantly lower rate than white workers (rate ratio [RR]=0.42, $p<0.05$). Overall, Hispanic workers had a higher rate than non-Hispanic workers (RR=2.35, $p<0.05$) and Hispanic construction workers had a higher rate than non-Hispanic construction workers (RR=2.51, $p<0.05$). Hispanic workers in AFFHM had a lower rate than their non-Hispanic counterparts (RR=0.72, not significant). Overall, male workers had a fatality rate that was 10 times that of female workers.

6.9. Industry by e-code

Fig. 5 shows the breakdown of fatalities by industry sector and e-code, which gives insight into the types of incidents that are occurring in the various industry sectors. Most of the groups, except for manufacturing, construction, and agriculture, forestry, fishing, and hunting have motor-vehicle incidents as their number one type of incident. Both transportation and warehousing (54%) and public administration (47%) have high percentages of their incidents due to motor vehicles. Wholesale trade and manufacturing have machinery accounting for approximately 27% of their incidents. The construction industry group had approximately one-third of its incidents due to falls. Of these, 12 out of 26 were due to falls from or out of buildings or other structures and 11 were due to falls from ladders or scaffolding.

7. Discussion

The WA FACE Program gets more than 50% of its case reports from the WISHA and workers compensation

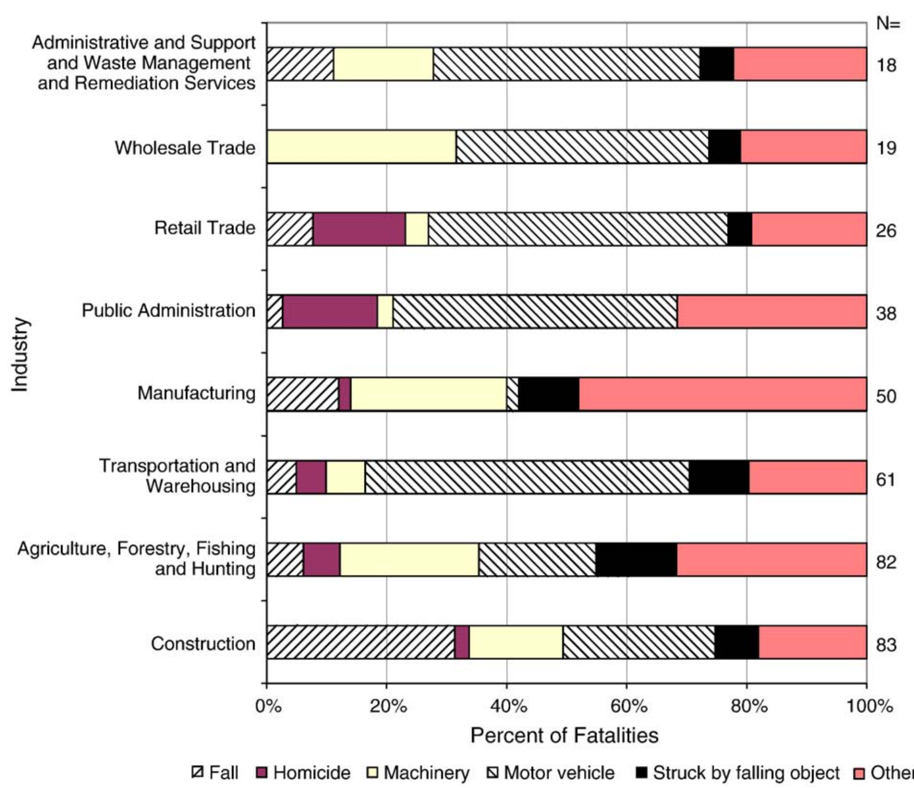

Fig. 5. Distribution of fatalities by industry sector and e-code.

programs. Both of these programs are located in the same state agency and building as the FACE Program and there are very strong personal and computer system linkages between the programs as well. This unique setting allows the FACE Program to be notified of cases in a timely manner and gives good access to reporting sources for follow-up questions about the incidents. These close relationships are critical for timely and accurate case ascertainment.

The average number of days between an incident and WA FACE being notified is relatively large, but is driven by a few incidents reported by our workers' compensation system and via death certificates. A workers' compensation claim may be filed within a year of death and some of the incidents take a number of months before a final decision to accept or reject the claim is made. Death certificates are initially filled out by the county medical examiners or coroners and sent to the State Department of Health where they are coded and entered into the computer. During the study period, we generally received death certificates with the "at work" field checked "yes," on a quarterly basis. If we have not been notified of an incident prior to receiving a death certificate, the incident may have occurred many months prior to our notification. These factors increase our notification times from these sources.

When the demographics of workers killed while on the job in Washington are compared to the nation (USBLS, 2003a), we find the ages are similar, though nationally 9% of the workers are older than 65 years of age versus 5% in Washington. The ethnicities of the workers are also similar, but there was a difference in race. In Washington, only 3% of our workers killed were African-American, while nationwide 9% were African-American. This reflects Washington's demographic pattern where approximately 3% of workers are African-American.

The distributions of incident types in Washington and the nation are difficult to compare directly because the FACE Program uses the ICD-9 e-codes (NCHS, 1979) to describe the incident type, while the U.S. BLS Program uses the Occupational Injury and Illness Classification System (OIICS; USBLS, 2002) Event codes. NIOSH's National Traumatic Occupational Fatality system uses e-codes, but is not as comprehensive as the CFOI system (Layne, 2004). Given the differences in coding systems, some gross comparisons are possible. Nationwide, 25% of fatalities are highway transportation-related, while in Washington 32% are motor-vehicle related. Nationwide, 13% and 11% of the workers die from falls and homicide, respectively, versus 11% and 7%, respectively in Washington. The machinery e-code is difficult to translate to the OIICS system for comparison.

The four occupations with the most fatalities in Washington have similar percentages in the nation, but Washington has relatively more farm workers and loggers dying than nationwide. Using the old SIC code system for industry description, in the top four industry divisions (construction; agriculture, forestry, fishing; transportation and public utilities; and manufacturing), Washington has similar percentages of fatalities, except for manufacturing where Washington has 18% and the nation has 10%. This difference is due to the large number of loggers killed in Washington.

Because the census asks people where they worked in the week prior to the census, for workers with non-fixed sites, there will be some misclassification in county-based fatality rates. If a logger was working in County 1 the week prior to the census and was killed when a tree fell on him in County 2 a week after the census, there would be a disconnect between the numerator and denominator in the calculation of rates. The scope of this issue is unknown, but by investigating fatality rates by county, and not county and industry in combination, we have minimized this problem.

Data were initially analyzed by SIC code and then changed to NAICS 2002 codes. This gives us a unique opportunity to compare results found when using the two different systems. Logging, highway construction, and police services remain relatively unchanged in their frequency-based rankings, but the trucking (SIC codes 4213 and 4212) and deciduous tree fruit (SIC 0175) industries get broken up and have lower rank (USCB, 2003), while long distance truckload truckers, site preparation contractors, and miscellaneous crop farming have higher ranks.

At the more aggregated 2 digit NAICS code level, there are two major differences between SIC and NAICS codes. There is an increase in the number of deaths in agriculture, forestry, fishing and hunting and corresponding decrease in the manufacturing sectors because logging was moved from manufacturing to forestry. There is a decrease in the number of deaths in transportation and public utilities because the utilities have been placed in their own sector. These changes are reflected in the rate calculations, though some extra aggregating was done to simplify the reporting (i.e., grouped utilities with transportation and warehousing and grouping some services together).

The estimated fatality rate for Washington between 1998 and 2002 was slightly lower than the national rate in 2002, 3.1 versus 4.0 deaths/100,000 workers. Because the CFOI Program only started to report fatalities by NAICS codes starting in the year 2003 (USBLS, 2004), it is difficult to compare our industry-specific fatality rates with that of the nation.

For most industries, the predominant incident type is motor-vehicle-related, but in construction; agriculture, forestry, fishing, and hunting; and manufacturing, falls, machinery-related, and struck by falling objects are the predominant sources. These observations are consistent with the findings of others (Paulozzi, 1987; Buskin & Paulozzi, 1987; Pollack et al., 1996; Myers & Hard, 1995) and observed hazards and exposures. Most of the "struck by falling objects" in agriculture, forestry, fishing, and hunting is in the logging industry, which would differ from pre-2003 CFOI data, where logging is in the manufacturing sector.

Given the fact that motor vehicles were associated with one-third of all work-related fatalities in the state and for some industry sectors they account for more than half of all fatalities, more effort needs to be put into the prevention of work-related motor-vehicle collisions. There are four major approaches to take in this direction: (a) have drivers drive safer, (b) have safer roadways, (c) have safer vehicles to prevent collisions, and (d) have safer vehicles that prevent injury once a collision has occurred. These routes of prevention have different groups who can control the actions (drivers, government, and vehicle manufacturers) and level of effectiveness. By focusing on driver safety, we are relying on people to make "safe decisions." This is the least effective strategy. We need to combine driver safety with the safest roads and vehicles that we can to reduce the impact of poor driver decision making, adverse weather conditions, and congested roadways. Because of the interconnectedness of these factors, it will take a coordinated effort to reduce work-related motor-vehicle collisions.

Other groups have investigated some of the specific hazards in depth such as motor-vehicle crashes (Loomis, 1991), pressurized air vessels in construction (Welch, Weeks, & Hunting, 1999), cranes in construction (Suruda, Liu, Egger, & Lillquist, 1999), forklift trucks (Collins et al., 1999), helicopter external load hazards (Manwaring, Conway, & Garrett, 1998), and falls in construction (Derr, Forst, Chen, & Conroy, 2001). These types of studies provide more information on the specific hazards that can be used for specific prevention activities.

For most epidemiological analyses, the coding scheme used is critical. The existing coding schemes used by FACE overlooked important themes. There were a large number of log truck driver fatalities. There is no specific code to identify these workers because they work for logging companies, trucking companies, saw mills, or may be self-employed. In this case, we used a text search method to find these incidents and review each one to ensure its validity as a case. We found that 11 log truck drivers had been killed between 1998 and 2002. Six were driving when their vehicle left the roadway, two were involved in collisions with other log trucks, and two were struck by logs during loading or unloading. This analysis allowed us to develop educational/outreach materials that were sent to nearly 1,000 recipients who were mainly log truck drivers, their companies, and sawmills (Washington State Fatality Assessment and Control Evaluation [WAFACE] Program, 2003). Similar problems are found when agricultural drowning and road construction work zones are investigated. These topics are the subject of past (WAFACE, 2002a, 2004a) prevention-based outreach/educational materials by the WA FACE Program. Because of the worker population involved, the document on agricultural drowning was translated into Spanish as well (WAFACE, 2002b).

In industry sectors that have contact with the public (retail trade, service, and public administration), there were a relatively large number of homicides, though our findings are not consistent with those found nationwide. In Washington, 16% of fatalities in public administration are homicides, while nationwide they were 22%. In Washington's service sectors, 6% of the fatalities were homicides versus 25% nationwide, retail trade had 15% versus 58%, and wholesale trade had 0 versus 14% (USBLS, 2003a). Although industry divisions that generally have regular contact with the public have been reported to be at greater risk nationally, the percentages were smaller in Washington for work-related homicide.

With any surveillance system, there is the potential for underestimation because not all reports of fatalities are sent to the system, but by using a multi-sourced system (Stout & Bell, 1991) that is similar to CFOI's (Layne, 2004) and having good linkages to most of the data sources, as we have, we have minimized the potential for missing a large number of reports from the major sources. Another source of under-reporting bias would be from under-reporting of fatalities to the authorities (someone dies and the incident is not reported to WISHA/OSHA or the workers' compensation system or the incident is not identified as work-related by the medical examiner or coroner).

In a filter model presented by Azaroff, Levenstein, and Wegman (2002) there are a number of "filters" that can explain under-reporting of occupational illnesses and injuries. For fatalities, the most important filter would probably be "Recognition of Work-Related Injuries and Illnesses," by first responders, caregivers, and medical examiners and coroners. This may be an industry or incident-specific bias. With most fixed industries, when a worker is killed on the job, it is obvious that they were at work. For workers who are driving and have a motor vehicle crash, especially while driving a non-commercial vehicle, it may be difficult for the authorities to assess whether the victim was in work status. In fishing and some farming activities, it may also be difficult for authorities to determine work status of the victim and if the incident does not get into the news media, it is possible that the incident may never be brought to the attention of our surveillance system to even evaluate.

By unifying the reporting of fatalities within the agency and the business and labor communities, and by highlighting individual incidents and groups of incidents, the WA FACE Program has prevented the death of workers going unnoticed. The WISHA Program investigates many of the incidents and can fine the company if regulations are violated. This mode of prevention directly affects generally one company, though the "word gets out" may have secondary effects. The FACE Program develops root-cause-based investigation reports (WAFACE, 2004b) case series highlighting multiple incidents with similar circumstances, and fatality narratives that highlight single incidents in the construction industry. These materials are sent to industry- and hazard-specific audiences and published on a web site (http://www.Lni.wa.gov/safety/research/face). The fatality narratives are used as the basis for construction industry hazard awareness sessions.

In addition to notifying the industry of fatalities and developing prevention materials, the FACE Program has served as an information source and repository for executives in the agency by sending out notices of all fatalities and periodic data updates. In addition to giving agency executives more information on fatalities, these activities bring more attention to all workplace fatalities, not only those that garner more media and WISHA coverage.

8. Conclusions

The ultimate use of an injury surveillance system is for the prevention of the injuries under surveillance. With guidance from the surveillance system, we developed a number of prevention activities, including training sessions and educational materials highlighting specific hazards or fatal incidents. Some of these activities have been focused on logging, log truck driving, drowning in agriculture, the construction industry in general, and construction work zones. Some of these activities have been initiated by single incidents, but others from a relatively large number of incidents of similar types. Intimate knowledge of the cases, with a memory of past similar cases, needs to be used to identify potential high prevalence incident types prior to developing a more complex code- and text-based search. Our prevention materials on drowning in agriculture, log truck-related fatalities, and fatalities in construction work zones would never have been identified as hazards through typical surveillance methods. Using a case series method highlighted by Park (2002), we can gain much information that may be applied for prevention.

One factor to further investigate at a national-level would be occupation and industry-specific fatality rates by ethnicity and region of the country. We found that certain industries, counties, and ethnic groups have higher fatality rates than others. Are these measures only surrogates for inherently hazardous jobs? This line of research would allow us to get at questions such as: “Do Hispanic workers in construction have a higher fatality rate because they take the more hazardous jobs that would kill a non-Hispanic worker with the same frequency, or are there other issues (communication, social, etc.) that are causing the higher rate?”

To get the information to the people needing it, we recommend that county or regional-level and industry profiles be developed and distributed to the local health jurisdictions, county extension offices, and business and labor associations. When targeted information (e.g., the high incidence of falls in construction) is delivered at a local level or to a specific group (e.g., construction workers), especially if the message is designed to “hit closer to home,” it can be used much more effectively than general data in preventing injuries. Industry-specific profiles (WAFACE, 2002c, 2004c, 2004d) and prevention materials (WAFACE, 2004e) may work toward this goal.

Acknowledgments

The surveillance system, analyses, and prevention activities described in this manuscript have been jointly funded by the Washington State Department of Labor and Industries and the National Institute for Occupational Safety and Health cooperative agreement number CCU013928–07. The author would like to thank Nayak Polliser of Mountain WhisperLight for his input on the confidence limit calculations.

References

Agnew, J., & Suruda, A. J. (1993). Age and fatal work-related falls. *Human Factors*, *35*, 731−736.

Austin, C. (1995). An evaluation of the census of fatal occupational injuries as system for surveillance. *Compensation and Working Conditions*, *1*, 51−54.

Azaroff, L. S., Levenstein, C., & Wegman, D. H. (2002). Occupational injury and illness surveillance: Conceptual filters explain underreporting. *American Journal of Public Health*, *92*, 1421−1429.

Buskin, S. E., & Paulozzi, L. J. (1987). Fatal injuries in the construction industry in Washington State. *American Journal of Industrial Medicine*, *11*, 453−460.

Collins, J. W., Landen, D. D., Kisner, S. M., Johnston, J. J., Chin, S. F., & Kennedy, R. D. (1999). Fatal occupational injuries associated with forklifts, United States, 1980–1994. *American Journal of Industrial Medicine*, *36*, 504−512.

Conroy, C., & Sciortino, S. (1997). Describing patterns of occupational agricultural deaths: The effect of case definition. *Journal of Safety Research*, *28*, 273−281.

Conway, G. A., Lincoln, J. M., Husberg, B. J., Manwaring, J. C., Klatt, M. L., & Thomas, T. K. (1999). Alaska's model program for surveillance and prevention of occupational injury deaths. *Public Health Reports*, *114*, 550−558.

Derr, J., Forst, L., Chen, H. Y., & Conroy, L. (2001). Fatal falls in the US construction industry, 1990 to 1999. *Journal of Occupational and Environmental Medicine*, *43*, 853−860.

Higgins, D. N., Casini, V. J., Bost, P., Johnson, W., & Rautiainen, R. (2001). The fatality assessment and control evaluation program's role in the prevention of occupational fatalities. *Injury Prevention*, *7*(Suppl. 1), i27−i33.

Jenkins, E. L. (1994). Occupational injury deaths among females. The US experience for the decade 1980 to 1989. *Annals of Epidemiology*, *4*, 146−151.

Jeong, B. Y. (1999). Comparisons of variables between fatal and nonfatal accidents in manufacturing industry. *International Journal of Industrial Ergonomics*, *23*, 565−572.

Layne, L. A. (2004). Occupational injury mortality surveillance in the United States: An examination of census counts from two different surveillance systems, 1992–1997. *American Journal of Industrial Medicine*, *45*, 1−13.

Loomis, D., Dufort, V., Kleckner, R. C., & Savitz, D. A. (1999). Fatal occupational injuries among electric power company workers. *American Journal of Industrial Medicine*, *35*, 302−309.

Loomis, D., & Richardson, D. (1998). Race and the risk of fatal injury at work. *American Journal of Public Health*, *88*, 40−44.

Loomis, D. P. (1991). Occupation, industry, and fatal motor vehicle crashes in 20 states, 1986–1987. *American Journal of Public Health*, *81*, 733−735.

Manwaring, J. C., Conway, G. A., & Garrett, L. C. (1998). Epidemiology and prevention of helicopter external load accidents. *Journal of Safety Research*, *29*, 107−121.

Marshall, S. W., Kawachi, I., Cryer, P. C., Wright, D., Slappendel, C., & Laird, I. (1994). The epidemiology of forestry work-related injuries in New Zealand, 1975–88: Fatalities and hospitalisations. *New Zealand Medical Journal*, *107*, 434−437.

Myers, J. R., & Hard, D. L. (1995). Work-related fatalities in the agricultural production and services sectors, 1980–1989. *American Journal of Industrial Medicine*, *27*, 51−63.

National Center for Health Statistics [NCHS]. (1979). *International classification of diseases, 9th revision (ICD-9).* Hyattsville, MD: Author.

National Center for Health Statistics [NCHS]. (2003). *Physicians' handbook on medical certification of death. DHHS Publication No. (PHS) 2003–1108.* Hyattsville, MD: Author.

National Research Council [NRC]. (1987). *Counting injuries and illnesses in the workplace: Proposals for a better system. NTIS P888–159553.* Washington, DC: National Academy Press.

Ore, T. (1998). Women in the U.S. construction industry: An analysis of fatal occupational injury experience, 1980 to 1992. *American Journal of Industrial Medicine*, *33*, 256−262.

Park, R. M. (2002). Hazard identification in occupational injury: Reflections on standard epidemiologic methods. *International Journal of Occupational and Environmental Health*, *8*, 354−362.

Paulozzi, L. J. (1987). Fatal logging injuries in Washington state, 1977 to 1983. *Journal of Occupational Medicine*, *29*, 103−108.

Peek-Asa, C., Erickson, R., & Kraus, J. F. (1999). Traumatic occupational fatalities in the retail industry, United States 1992–1996. *American Journal of Industrial Medicine*, *35*, 186−191.

Pollack, E. S., Griffin, M., Ringen, K., & Weeks, J. L. (1996). Fatalities in the construction industry in the United States, 1992 and 1993. *American Journal of Industrial Medicine*, *30*, 325−330.

Prouty, A. M. (1985). *More deadly than war!: Pacific coast logging, 1827–1981.* New York, NY: Garland Publishing.

Stout, N., & Bell, C. (1991). Effectiveness of source documents for identifying fatal occupational injuries: A synthesis of studies. *American Journal of Public Health*, *81*, 725−728.

Suruda, A., Liu, D., Egger, M., & Lillquist, D. (1999). Fatal injuries in the United States construction industry involving cranes 1984–1994. *Journal of Occupational and Environmental Medicine*, *41*, 1052−1058.

Suruda, A., Philips, P., Lillquist, D., & Sesek, R. (2003). Fatal injuries to teenage construction workers in the US. *American Journal of Industrial Medicine*, *44*, 510−514.

Thomas, T. K., Lincoln, J. M., Husberg, B. J., & Conway, G. A. (2001). Is it safe on deck? fatal and non-fatal workplace injuries among Alaskan commercial fishermen. *American Journal of Industrial Medicine*, *40*, 693−702.

United States Bureau of Labor Statistics [USBLS]. (2002, October 9). *Occupational injury and illness classification (OIICS) manual.* Available at http://www.bls.gov/iif/oshoiics.htm (Accessed 20 2004).

United States Bureau of Labor Statistics [USBLS]. (2003a, September 17). *National census of fatal occupational injuries in 2002.* Available at http://www.bls.gov/iif/oshcfoi1.htm (Accessed 21 November 2003).

United States Bureau of Labor Statistics [USBLS]. (2003b). *Labor force statistics from the current population survey.* Available at http://www.bls.gov/cps/home.htm (Accessed 20 November 2003).

United States Bureau of Labor Statistics [USBLS]. (2004, September 22). *National census of fatal occupational injuries in 2003.* Available at http://www.bls.gov/iif/oshcfoi1.htm (Accessed 13 April 2005).

United States Census Bureau [USCB]. (1992). *Classified index of industries and occupations, 1990, Census of population and housing* (1990 CPH-R-4). Washington DC: U.S. Census Bureau, U.S. Dept. of Commerce.

United States Census Bureau [USCB]. (2000). *Census of population and housing, technical documentation (Summary File 3, 2000).* Available at http://www.census.gov/prod/cen2000/doc/sf3.pdf (Accessed 20 June 2004).

United States Census Bureau [USCB]. (2003, April). *Correspondence Tables: 1987 SIC Matched to 2002 NAICS.* Available at http://www.census.gov/epcd/naics02/S87TON02.HTM (Accessed July 2004).

United States Census Bureau [USCB]. (2004, January 14). *North American industry classification system (NAICS).* Available at http://www.census.gov/epcd/www/naics.html (Accessed 20 February 2004).

Washington State Census of Fatal Occupational Injuries Program [WAFACE]. (2003). Available at http://www.lni.wa.gov/ClaimsInsurance/Files/DataStatistics/blsi/FATAL2002CROIWA.pdf

Washington State Fatality Assessment and Control Evaluation Program [WAFACE]. (2002a). *Drowning dangers on agricultural lands.* Available at http://www.lni.wa.gov/Safety/Research/FACE/files/ag_drown.pdf (Accessed 2 July 2004).

Washington State Fatality Assessment and Control Evaluation Program [WAFACE]. (2002b). *Peligros de ahogarse en terrenos agricolasa.* Available at http://www.lni.wa.gov/Safety/Research/FACE/files/agdrown_sp.pdf (Accessed 2 July 2004).

Washington State Fatality Assessment and Control Evaluation Program [WAFACE]. (2002c). *Work-related agricultural fatalities in Washington State, 1998–2001.* Available at http://www.lni.wa.gov/Safety/Research/FACE/files/ag_rep02.pdf (Accessed 2 July 2004).

Washington State Fatality Assessment and Control Evaluation Program [WAFACE]. (2003). *Hazards on the road for log truck drivers.* Available at http://www.lni.wa.gov/Safety/Research/FACE/files/LogTruck.pdf (Accessed 2 July 2004).

Washington State Fatality Assessment and Control Evaluation Program [WAFACE]. (2004a). *Roadway work zones: Hazards to workers on foot.* Available at http://www.lni.wa.gov/Safety/Research/FACE/files/WorkZones.pdf (Accessed 13 April 2005).

Washington State Fatality Assessment and Control Evaluation Program [WAFACE]. (2004b). *Fatality investigation reports.* Available at http://www.lni.wa.gov/Safety/Research/FACE/ReptNarr/default.asp#FatalityInvestigationReports (Accessed 2 July 2004).

Washington State Fatality Assessment and Control Evaluation Program [WAFACE]. (2004c). *Construction fatalities supplement, 2004.* Available at http://www.lni.wa.gov/Safety/Research/FACE/files/consup04.pdf (Accessed 2 July 2004).

Washington State Fatality Assessment and Control Evaluation Program [WAFACE]. (2004d). *Logging-related fatalities, 1998–2003.* Available at http://www.lni.wa.gov/Safety/Research/Face/files/logrep2004.pdf (Accessed 2 July 2004).

Washington State Fatality Assessment and Control Evaluation Program [WAFACE]. (2004e). *Fatality narratives.* Available at http://www.lni.wa.gov/Safety/Research/FACE/ReptNarr/default.asp#FatalityNarratives (Accessed 2 July 2004).

Welch, L. S., Weeks, J., & Hunting, K. L. (1999). Fatal and non-fatal injuries from vessels under air pressure in construction. *Journal of Occupational and Environmental Medicine*, *41*, 100−103.

Windau, J., Sygnatur, E., & Toscano, G. (1999). Profile of work injuries incurred by young workers. *Monthly Labor Review*, 3−10.

Marty A. Cohen was the Industrial Hygiene Research Manager at the SHARP Program at the Washington State Department of Labor and Industries when this work was conducted. At that time, he was the principal investigator for the Washington State Fatality Assessment and Control Evaluation (FACE) Program. He is currently a Research Scientist at the University of Washington. He received his S.M. and Sc.D. from the Harvard School of Public Health in Environmental Health Sciences.

Randy Clark is the Data Manager for the Washington State Fatality Assessment and Control Evaluation (FACE) Program and a Research Analyst for the SHARP Program within the Washington State Department of Labor and Industries. He received his BA degree in Journalism from the Evergreen State College.

Barbara Silverstein is the Research Director of the Washington State Department of Labor and Industries' SHARP Program. She received her MS degree in nursing from the University of California San Francisco, her MPH in Epidemiology and Environmental and Industrial Health from the

University of Michigan, and her Ph.D. in Epidemiologic Science from the University of Michigan. She has worked on ergonomics-related issues at OSHA, the University of Michigan Center for Ergonomics, the Finnish Institute of Occupational Health, and the California Department of Health Services. Her major areas of research have been identification and control of work-related musculoskeletal disorders, comparison of surveillance methods and intervention studies to control these disorders. She serves on a number of national and international commissions and editorial boards regarding occupational safety and health.

Tom Sjostrom is a Safety Engineer in the Washington State Department of Labor and Industries' SHARP Program. Tom is a graduate of Mitchell College, New London, CT in General Science and Engineering and has a BS in Occupational Safety and in Industrial Hygiene from the University of New Haven, CT. Tom also attended the University of New Haven Graduate School for an MS in Environmental Engineering/Environmental Science. Tom worked as a Research Scientist with a Pharmaceutical company and as a Health and Safety Manager and Safety Director in the Pharmaceutical, Chemical, Forest Products/Pulp and Paper Industries. Tom is a member of the Hazardous Materials Control Research Institute, ASSE, AIHA, NFPA, ASCE. He supports the FACE Program and health and safety research within SHARP.

Peregrin Spielholz is an Investigator with the Washington State Department of Labor and Industries' SHARP Program. He completed his BSE and MSE at the University of Michigan and his PhD at the University of Washington. His areas of focus are accident investigation, safety engineering, human-centered design and the assessment of workplace risk factors and interventions. Peregrin is a Certified Professional Ergonomist (CPE) and a Certified Safety Professional (CSP). He has worked with companies and organizations across the country in most industry sectors. He has published extensively in ergonomics and occupational safety and health. Peregrin is the Principal Investigator for the NIOSH-funded Fatality Assessment and Control Evaluation (FACE) Program in Washington State and an Affiliate Assistant Professor at the University of Washington's Department of Environmental and Occupational Health Sciences.