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Lifetime Risk of Fatal Occupational Injuries within Industries, by Occupation, Gender, and Race

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ABSTRACT

Estimates of risk accumulated over a working lifetime are used to assess the significance of many workplace health hazards. Most studies which have estimated this risk have focused on a worker's lifetime risk of dying of a stated illness based on exposure to a hazard in a specific job. The concept, however, has not been widely applied to occupational injury deaths. This study examines the use of lifetime risk based on national fatal injury data from the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI). Lifetime risks are defined by specific causal events for those groups identified as having the highest general lifetime risks. The lifetime risk model for injury used in this work can be compared with risk assessments for occupational illnesses. Fatal injury lifetime risk estimates will be useful in defining traumatic injury exposures that are appropriate for targeting research and prevention efforts needed to reduce the burden of work-related death within the United States. These estimates also provide a means of prioritizing traumatic injury research with fatal illness research, while providing the additional benefit of providing a means of informing workers of their fatal injury risks.

Key Words: occupational injury death, cause of death, high-risk job

INTRODUCTION

Estimates of risk accumulated over a working lifetime are used to assess the significance of many workplace health hazards. Most studies that have esti-

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mated this risk have focused on a worker's lifetime risk of dying of a stated illness based on exposure to a hazard in a specific job (Palmer and Rickett, 1992; Nurminen *et al*., 1992; Stayner *et al*., 1992; Smith and Stayner, 1990; Hodgson and Jones, 1990). The concept, however, has not been widely applied to occupational injury deaths. A recent study done by Fosbroke *et al*. (1997) did estimate the average lifetime risk of work-related fatal injuries. The results from the study suggest that, when lifetime risk is considered for traumatic injuries, the risks for specific causes of death for certain occupations are of the same magnitude as cancer risks reported for specific occupational exposures. Based on these findings, risk assessment for traumatic causes of death should be considered equally with risk assessments for certain health exposures.

The purpose of this work was to build upon the recent study done by Fosbroke *et al*. (1997). The current study examined the use of lifetime risk based on national fatality data from the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI). The objectives of the study were to define the general lifetime risk of occupational injury death within detailed industry and occupation combinations by gender or race; and to define cause-related lifetime risks for those groups identified as having the highest general lifetime risks. As in the previous study, this paper used a lifetime risk model for injury that can be compared with risk assessments for occupational illnesses.

METHODS

Occupational fatality data were extracted from the BLS CFOI for the years 1992 through 1996. The CFOI data include information on fatal work injuries occurring in the 50 states and the District of Columbia. The BLS uses multiple data sources to identify and verify these fatal work injuries. Information about each workplace fatality, such as occupation at the time of death and other worker characteristics and circumstances of the event, is obtained by cross-referencing source documents, including death certificates, workers' compensation records, and reports to Federal and State agencies (Toscano and Windau, 1997).

The detailed industry and occupation information in the CFOI data were coded using the Bureau of the Census (BOC) 1990 classification system (Bureau of Census, 1992). Denominator data were obtained from the 1992 through 1996 Current Population Survey (CPS) monthly employment files (Bureau of Labor Statistics, 1992).

The working lifetime risk was calculated using the same formula from the previous study:

$$\mathrm{WLTR} = \left[1 - \left(1 - \mathrm{R}\right)^{y}\right] \times 1000$$

where WLTR = Working Lifetime Risk; R = Ratio of the average annual number of work-related fatal injuries among workers of a given group to

average annual employment in that group; y = Years of exposure to work-related fatal injury risk.

The formula assumes R, which is a weighted average of deaths across all workers employed within a specific group, provides an unbiased measure of the risk for the group, on a population basis. R is equal to the average annual fatality rate for a specific group expressed as a simple proportion, rather than in units of some fixed number of exposed workers. The formula also assumes that the corresponding lifetime risk estimate is for a fixed initial population of 1000 workers. This means that the population at risk decreases with time (*i.e.*, the number of estimated deaths in year one are removed from the original starting population, and the number of deaths estimated for year two are based on the estimated number of survivors, and so on).

The value of R was estimated using all five years of data from the CFOI and the CPS. This was done to provide a more stable estimate of R for each group. The value of y was set at 45 years, as recommended by the Occupational Safety and Health Administration (OSHA)(1995) and Stayner (1992). The current study only included data for workers aged 20 through 64. This was done to better define worker risk during the defined 45-year working lifetime. The current study examines characteristics of the fatality based on the BLS Occupational Injury and Illness Classification System (OIICS) (National Safety Council, 1997). The OIICS includes five classification structures that describe the injury and how it occurred: nature of injury, part of body affected, source of injury, event or exposure, and secondary source of injury. Specifically, the current study examines the event or exposure which describes the manner in which the injury was sustained. This differs from the study done by Fosbroke *et al.* (1997), which examined cause of death characteristics by E-codes (E800–E999) found in the International Classification of Diseases, 9th Revision (World Health Organization, 1977). E-codes can be viewed as a combination of the event and source codes from the OIICS. To be included in this report, a minimum of five deaths was required for the calculation of a lifetime risk estimate, and the estimate had to be greater than one death per 1000 working lifetimes.

RESULTS

Demographics of Fatal Injuries

During the 5-year period, 1992 through 1996, there were 28,068 fatal occupational injuries in the United States according to the CFOI. Ninety two percent of these deaths were to male workers. Whites (excluding Hispanics) accounted for 73.5% of the worker fatalities, 10.7% were to African-American (excluding Hispanics) workers, and 9.9% were to Hispanic workers. An additional 3.9% were to workers of other races. The remaining 2% of deaths were among workers for whom race was unknown.

The five industries with the highest 5-year average annual fatal injury rates were logging (148 deaths, 112.4 deaths/100,000 workers), fishing, hunting and trapping (78 deaths, 99.6 deaths/100,000 workers), taxi cab services

(97 deaths, 95.3 deaths / 100,000 workers), coal mining (57 deaths, 48.6 deaths / 100,000 workers), and water transportation (70 deaths, 42.6 deaths / 100,000 workers). The four occupations with the highest average annual fatal injury rates were sailors (151 deaths, 177.6 deaths / 100,000 workers), loggers (535 deaths, 158.1 deaths / 100,000 workers), airplane pilots (622 deaths, 146.6 deaths / 100,000 workers), and fishers (304 deaths, 144.5 deaths / 100,000 workers).

The major event category that had the greatest number of deaths was transportation incidents, accounting for 40% of these fatal injuries. Other major event categories accounting for at least 2500 deaths were assaults and violent acts (20%), contact with objects and equipment (16%), falls (10%), and exposure to harmful substances or environments (10%). Two detailed event categories accounted for nearly a quarter of the fatal injuries—assaults and violent acts by shooting (14%) and highway collisions between motor vehicles or equipment (10%).

The number of deaths and the lifetime risk estimate are shown in Tables 1 through 6 for specific events occurring to workers of specific occupations within industries. Shown are the ten to fifteen combinations with the highest lifetime risks. Tables 1 and 2 provide results by gender. Tables 3 to 6 provide results for the following: white workers (excluding Hispanics); African-American workers (except Hispanics); Hispanic workers; and workers of other races. In all tables, the lifetime risk estimate is expressed as the number of deaths in 1000 45-year working lifetimes. For the female and other race categories, there were fewer than 15 combinations meeting our criteria of having a minimum of 5 deaths during the five year period and having a lifetime risk of at least 1.0 in 1000.

Gender

Table 1 provides the 15 combinations with the highest lifetime risks for male workers. The number of deaths ranged from a low of 10 to a high of 323. Three high-risk combinations had lifetime risk estimates greater than 100 / 1000 working lifetimes. An examination of the industries in Table 1 shows a clustering of risk around common, or similar work environments. Three high-risk groups were associated with logging, three were related to fishing or water transportation, and two were aircraft related. Four event categories were found to be the cause of death in more than one combination of industry and occupation: being struck by falling objects, homicides by shooting, boats sinking, and airplane crashes.

To better understand the circumstances of these high-risk events, other data elements, such as the narrative injury description, were reviewed for selected industry, occupation, and event combinations. Among male workers, the highest lifetime risk estimate was for airplane pilots in agricultural services killed in airplane crashes. Of the 62 deaths in this category, the narratives indicate that nearly all were associated with commercial spraying, or crop dusting. Athletes in business services, n.e.c. who died by drowning were prima-

Table 1. Highest 45-year working lifetime risks for male workers by industry, occupation, and cause of death, 1992–1996. The leading lifetime risk estimates are only presented for combinations that had a minimum of 5 deaths during this 5-year period.

Industry	Occupation	Event	Deaths	Lifetime risk[a]
Agricultural services	Airplane pilots	Airplane crashes	62	308.9
Grocery stores	Sales counter clerks	Homicide by shooting	14	147.6
Business services, N.E.C.	Athletes	Drowning	11	106.6
Air transportation	Airplane pilots	Airplane crashes	291	59.1
Logging	Logging supervisors	Struck by falling objects	31	55.8
Administration of Environmental Quality and Housing Programs	Firefighters	Forest/outdoor fire	10	54.5
Taxi cab service	Taxi cab drivers	Homicide by shooting	323	50.8
Logging	Loggers	Struck by falling object	304	43.1
Fishing/hunting/trapping	Captains of vessels	Boat sinking	31	38.2
Eating/drinking places	Guards (private)	Homicide by shooting	37	31.2
Water transportation	Sailors	Fall from ship	32	28.4
Personnel supply services	Truck drivers	Highway collision other vehicle	15	28.4
Logging	Sawing machine operators	Struck by falling objects	12	28.2
Fishing/hunting/trapping	Fishers	Boat sinking	106	24.3
Construction	Elect. power installers	Contact with overhead power lines	20	19.6

[a] Lifetime risk are in units of deaths per 1000 45-year working lifetimes.

Table 2. Highest 45-year working lifetime risks for female workers by industry, occupation, and cause of death, 1992–1996. The leading lifetime risk estimates are only presented for combinations that had a minimum of 5 deaths during this 5-year period.

Industry	Occupation	Event	Deaths	Lifetime risk[a]
Trucking services	Truck drivers	Highway noncollision	17	5.6
Air transportation	Public transport attendants	Airplane crashes	28	5.4
Construction	Construction laborers	Pedestrian struck by vehicle in roadway	13	5.4
Trucking services	Truck drivers	Highway Collision other vehicle	13	4.3
Trucking services	Truck drivers	Collision stationary object on side of road	12	3.9
General gov, N.E.C.	Office clerks	Homicide by violence N.E.C.	5	3.8
Direct sales estab.	News vendors	Highway collision other vehicle	5	3.5
Eating/drinking places	Supervisors/proprietors	Homicide by shooting	5	3.4
Newspaper pub/printing	News vendors	Highway collision other vehicle	6	2.2
Laundry, cleaning, garment services	Sales counter Clerks	Homicide by shooting	6	1.3
Gas service stations	Cashiers	Homicide by shooting	8	1.3
Grocery stores	Supervisors/proprietors	Homicide by shooting	28	1.1
General gov, N.E.C.	Secretaries	Homicide by violence N.E.C.	5	1.0
Agricultural crops	Farm workers	Off road noncollision	6	1.0

[a] Lifetime risk are in units of deaths per 1000 45-year working lifetimes.

Table 3. Highest 45-year working lifetime risks for white workers, excluding Hispanics, by industry, occupation, and cause of death, 1992–1996. The leading lifetime risk estimates are only presented for combinations that had a minimum of 5 deaths during this 5-year period.

Industry	Occupation	Event	Deaths	Lifetime risk[a]
Agricultural services	Airplane pilots	Airplane crashes	59	310.0
Business services, N.E.C.	Athletes	Drowning	11	104.9
Air transportation	Airplane pilots	Airplane crashes	285	77.6
Administration of environmental quality and housing programs	Fire fighters	Forest/outdoor fire	14	73.4
Logging	Logging supervisors	Stuck by falling objects	27	48.8
Taxi cab services	Taxi cab driver	Homicide by shooting	120	40.7
Logging	Loggers	Struck by falling objects	236	40.1
Fishing/hunting/trapping	Captain of vessels	Boat sinking	25	35.8
Grocery stores	Sales counter clerks	Homicide by shooting	13	33.5
Personal supply	Truck drivers	Highway Collision. other vehicle	12	33.5
Construction	Elect. power installers	Contact with overhead power lines	18	23.3
Fishing/hunting/trapping	Fishers	Boat sinking	83	20.8
Water transportation	Sailors	Fall From Ship	19	19.0
Construction	Elect. power installers	Contact wiring, transformers	12	15.6
Saw mills	Loggers	Struck by falling objects	10	14.3

[a] Lifetime risk are in units of deaths per 1000 45-year working lifetimes.

Table 4. Highest 45-year working lifetime risks for African-American workers, excluding Hispanics, by industry, occupation, and cause of death, 1992–1996. The leading lifetime risk estimates are only presented for combinations that had a minimum of 5 deaths during this 5-year period

Industry	Occupation	Event	Deaths	Lifetime risk[a]
Eating/drinking estab.	Guards (private)	Homicide by shooting	16	107.0
Taxi cab services	Taxi cab drivers	Homicide by shooting	137	66.7
Logging	Loggers	Struck by falling objects	56	58.4
Construction	Roofers	Fall From roof	13	8.1
Grocery stores	Supervisors/proprietors	Homicide by shooting	30	7.2
Trucking services	Truck drivers	Highway Collision other vehicles	56	6.3
Trucking services	Truck drivers	Highway Noncollision	52	5.8
Taxi cab services	Taxi cab drivers	Highway Collision other vehicles	10	5.0
Trucking services	Truck drivers	Highway collision stationary obj. on side of the road	42	4.7
Gas service stations	Cashiers	Homicide by shooting	6	4.5
Protective services	Guards (private)	Homicide by shooting	41	4.5
Agricultural crops	Farm workers	Off road noncollision	13	4.3
Grocery stores	Cashiers	Homicide by shooting	32	4.1
Public Safety	Police (public)	Homicide by shooting	29	4.0
Construction	Operating engineers	Off road noncollision	5	3.8

[a] Lifetime risk are in units of deaths per 1000 45-year working lifetimes.

Table 5. Highest 45-year working lifetime risks for Hispanic workers by industry, occupation, and cause of death, 1992–1996. The leading lifetime risk estimates are only presented for combinations that had a minimum of 5 deaths during this 5-year period

Industry	Occupation	Event	Deaths	Lifetime risk[a]
Taxi cab services	Taxi cab driver	Homicide by shooting	46	49.5
Gas service stations	Cashiers	Homicide by shooting	12	13.1
Grocery store	Supervisors/proprietors	Homicide by shooting	52	12.2
Protective services	Guards (private)	Homicide by shooting	31	9.5
Construction	Roofers	Fall from roof	33	8.5
Eating/drinking places	Bartenders	Homicide by shooting	9	7.1
Grocery store	Cashiers	Homicide by shooting	37	6.0
Direct sales estab.	Door-to-door salesmen	Homicide by shooting	15	5.9
Trucking services	Truck drivers	Highway Noncollision	33	5.8
Trucking services	Truck drivers	Highway collision other vehicle	28	4.9
Public order	Police (public)	Homicide by shooting	19	4.6
Trucking services	Truck drivers	Highway collision stationary obj. on side of the road	26	4.6
Agricultural services	Farm workers	Off-Road Noncollision	8	3.0
Construction	Electricians	Contact with wiring, transformers, etc...	7	2.9
Automotive repair	Auto body repairers	Homicide by shooting	6	2.8

[a] Lifetime risk are in units of deaths per 1000 45-year working lifetimes.

Table 6. Highest 45-year working lifetime risks for workers of other races, excluding Hispanics, whites, and African-Americans, by industry, occupation, and cause of death, 1992–1996. The leading lifetime risk estimates are only presented for combinations that had a minimum of 5 deaths during this 5-year period.

Industry	Occupation	Event	Deaths	Lifetime risk[a]
Fishing/hunting/trapping	Fishers	Fall from ship	14	41.7
Gas service station	Service station occup.	Homicide by shooting	14	36.7
Taxi cab services	Taxi cab drivers	Homicide by shooting	26	33.2
Liquor stores	Supervisors/proprietors	Homicide by shooting	16	30.0
Grocery stores	Supervisors/proprietors	Homicide by shooting	90	24.9
Grocery stores	Cashiers	Homicide by shooting	58	16.8
Grocery stores	Stock handlers/baggers	Homicide by shooting	9	6.1
Trucking services	Truck drivers	Highway collision stationary obj. on side of the road	5	4.3
Trucking services	Truck drivers	Highway noncollision	5	4.3
Grocery stores	Supervisors/proprietors	Homicide by stabbing	5	1.4

[a] Lifetime risk are in units of deaths per 1000 45-year working lifetimes.

rily commercial divers (1 case was inconclusive). All 10 deaths of firefighters by forest or outdoor fires in the Administration of Environmental Quality and Housing Programs industry appeared to be associated with a single event. Finally, the guards in eating/drinking establishments classified as homicide by shooting appear to be guards in bars (*e.g.*, bouncers, doormen).

The high-risk groupings for female workers were different from those for male workers (Table 2). Only two combinations that occurred among the high-risk male groups also occurred among females: homicides by shooting in eating/drinking places and homicides by shooting in grocery stores. Even here, the occupational classifications were slightly different, with females being classified as proprietors/supervisors, while males were guards and sales counter clerks, respectively. The number of deaths for these fourteen high-risk groups of female workers ranged from a low of 5 deaths to a high of 28 deaths. The highest lifetime risk estimate for female workers was 5.6 per 1000 working lifetimes. Homicide by shooting, highway collisions with other vehicles, and homicide by violence n.e.c., were the event categories that appeared in more than one occupation by industry combination for female workers.

Among female workers, two high-risk combinations accounted for 10 deaths in the industry category of general government, n.e.c. Five were secretaries and five were office clerks. All 10 were due to homicide by violence n.e.c., and appeared to be associated with a single event. Of the 13 deaths among female construction laborers due to being struck by vehicle in roadway, 6 were working as flaggers, 10 were struck by motor vehicles, and 3 were struck by equipment in the work zone.

Race

The risk profile for white workers (Table 3) was similar to the risk profile for male workers. Air crashes among airplane pilots in air transportation and drowning among athletes in business services, n.e.c. again had life time risk estimates greater than 100 in 1000. Among African-American workers (Table 4), private guards employed in eating and drinking establishments, who were killed by homicides due to shootings, had a lifetime risk estimate greater than 100 in 1000. No lifetime risk estimates for Hispanic workers (Table 5) or workers of other race (Table 6) exceeded 100 in 1000.

Some combinations of industry, occupation, and event were among the highest lifetime risks for two or more racial categories. For example, homicide by shooting among taxi drivers in taxi cab services was a high-risk event for all four racial categories with lifetime risk estimates varying from a low of 33.2 for workers of other races to a high of 66.7 for African-American workers. Being struck by falling objects among loggers in the logging industry was a high-risk event for white and African-American workers, where lifetime risk estimates were 40.1 and 58.4, respectively. Four injury hazards were identified among the high lifetime risks for African-American and Hispanic workers, as well as workers of other races. Two involved homicide by shooting in grocery stores where the victim was either a supervisor/proprietor or a cashier. The other

two involved highway collisions with a stationary object on the side of roadway or a highway noncollision incident. Truck drivers in trucking services were the victims in both of these transportation events.

DISCUSSION

This analysis of fatal occupational injury provides a priority list for research and intervention efforts to better understand and reduce workplace fatalities. Traditionally, occupational injury research has been based on the univariate analysis of industry, occupation, and cause of death, or by combining these variables in broad categories. While these analyses have been useful in identifying major areas that required further research, they tend to mask high-risk groups. Risks do differ by race or gender categories within detailed industry and occupation classification systems. To better define these differences, this work has identified the highest fatal injury risks in United States' workplaces for those race and gender categories exposed to specific fatal injury events using detailed industry and occupation classification systems.

By focusing on event, occupation, and industry combinations that had the greatest lifetime risk, we have confirmed earlier targeted reports on some high-risk groups and identified some previously unidentified groups. Risks to loggers in the logging industry have been reported by NIOSH previously (Myers and Fosbroke, 1994; Braddee, 1994). Risks to taxi cab drivers have also been reported previously (Castillo and Jenkins, 1994; Toscano and Windau, 1997). Finally, fatality concerns for commercial fishermen have been documented (Bender, 1994; Conway, 1994; Kennedy, 1994). Risks that have not been previously reported include commercial divers, commercial crop dusters and aerial spraying pilots, as well as African-American males who work as bouncers for eating and drinking establishments.

The ranking of the industries with the five highest lifetime risk estimates in this study was identical to a prior analysis conducted using the National Traumatic Occupational Fatalities (NTOF) data (Fosbroke *et al*., 1997). However, due to CFOI's more complete capture of work-related fatal injuries, the lifetime risk estimates presented in this paper are higher. In terms of occupation, two occupations (structural metal workers and extractive occupations) were among the top five in the NTOF lifetime risk analysis, but not among the top five in the CFOI analysis. In the prior study, sailors and deck hands were combined into a single occupation group called water transport occupations because of the use of printed employment estimates from the BLS. In this current study, estimates are given for each occupation separately because detailed employment data, maintained by BLS in an electronic format, were used.

Results by gender and race categories define risks faced by specific subgroups of the U.S. workforce. The results for females indicate that, while they do not have lifetime risk estimates as high as those for males, there are still 14 occupations within industries that meet or exceed what OSHA considers a significant lifetime risk, 1 death per 1000 working lifetimes (Adkins, 1993).

Lifetime risks by racial groups are also valuable, not only to verify that specific occupations have high risks across all racial groups (*e.g.*, taxi cab drivers, truck drivers, loggers, fishermen), but also to identify specific injury risks for minority racial groups. These race- and gender-specific lifetime risks allow public health professionals and researchers to better target research and prevention efforts in these more defined populations.

This analysis of CFOI data underscores the necessity for maintaining narrative data describing injury events, as well as data such as the day of week, the year of injury, and other descriptive variables. Through examination of these additional fields, it was possible to identify airplane pilots in agricultural services as being commercial applicators, or crop dusters. These variables were also useful for identifying multiple fatality events, such as those of government workers in an apparent single act of violence and those of the fire fighters in an apparent single wildland fire.

Though these multiple fatality events might be discounted as aberrations, readers should be careful in assuming that they are without merit. The death of 14 fire fighters (10 of them males) in a single fire accounts for why this group is on the table of high-risk injury exposures, but such multiple fatality events for wildland firefighters are not unprecedented. In 1953, the Rattlesnake fire in the Mendocino National Forest took the lives of 15 firefighters (Isner and Baden, 1995). These two tragic events are separated by a span of 41 years, which is contained within the 45-year working lifetime defined for this paper. Also during this 41-year time period, a third wildland fire claimed the lives of 12 fire fighters in 1966 (Williams, 1995). Thus, while the lifetime risk presented for these fire fighters is likely too high due to chance, the occurrence of three such events in 41 years would still suggest a risk of over 20 deaths per 45-year working lifetimes. This high-risk for wildland fire fighters also suggests that periodic major disasters may be very influential in evaluating the lifetime risk of certain occupations. Based on this, it is possible that this study missed other high-risk groups that are associated with periodic multiple fatality events (*e.g.*, coal miners and mine explosions).

For this study, we assumed a working lifetime of 45 years starting at age 20. The exclusion of workers less than 20 years of age and those greater than age 65 years of age does have implications for the estimation of lifetime risk. First, since the lifetime risk formula is a power function, extension of working lifetime beyond 45 years would naturally increase the expected number of deaths per 1000 working lifetimes. Second, based on prior studies of fatal occupational injury (Kisner and Pratt, 1997; Toscano and Windau, 1997), work-related fatal injury rates are greater for workers over age 65 than for workers age 20 to 65. This is especially true for some specific worker populations, such as agricultural workers (Myers and Hard, 1995). Thus, if older workers were included in the lifetime risk calculations, the ranking of specific injury hazards could change from those reported here. However, restricting the ages for estimating lifetime risks does allow for a better estimate of risk for the predominate age period when most individuals are working. The 20 to 64 age group does show the most consistency in their hours worked (Ruser,

1998). This age range also more closely follows the typical working lifetime and age range considered by others who conduct research on occupational exposures to health hazards (Stayner, 1992).

There are other issues related to the selection of data sources in this study. For example, the CFOI uses the Standard Industrial Classification (SIC) system (Office of Management and Budget, 1987) for categorizing industry, while the CPS uses the Bureau of the Census (BOC) industry classification system. The SIC codes are more specific than the BOC codes and can be collapsed into the BOC categories. This precludes the calculation of lifetime risk estimates for detailed SIC industry categories, such as those under the construction industry. The CFOI also uses the Occupational Injury and Illness Classification System (OIICS) to describe the injury event, rather than the International Classification of Diseases-Ninth Revision (ICD-9), E-Code. Therefore, the injury risks described by this study differ somewhat from risks reported based on E-Codes (Fosbroke *et al.*, 1997; Jenkins *et al.*,1993).

Some of the industry and occupation combinations that have the highest lifetime risks are relatively small in terms of employment. This includes white pilots in agricultural services (approximately 1600 workers), male sales clerks in grocery stores (approximately 800 workers), male commercial divers in business services n.e.c. (approximately 900 workers), African- American guards in eating and drinking establishments (approximately 1300 workers), white wildland firefighters (approximately 1700 workers), and male logging supervisors in logging (approximately 4900 workers). To some extent, these lifetime risk estimates may be less stable compared to those estimates presented where employment is substantially higher, both because of the employment estimates used to calculate the lifetime risks, and because of annual variations in the number of fatalities occurring to such groups. This would result in higher variance estimates for these low employment groups. Still, many of these groups with low employment show high numbers of fatalities (*e.g.*, pilots in agricultural services at 62 deaths, logging supervisors at 31 deaths) to justify their consideration as a major concern. In addition, high-risk occupations within industries tend, in general, to be associated with low employment. Only six of the combinations identified on Tables 1 through 6 represent an "occupation within industry" annual employment above 60,000 workers (male loggers within logging, female proprietors or supervisors in grocery stores, African-American truck drivers in trucking services, African-American private guards in protective services, African-American cashiers in grocery stores, and African-American public police in public safety).

The use of the CPS as an employment source also creates some limitations in the estimation of lifetime risks. Because of the nature of the CPS, lifetime risks calculated here were based on the workers primary industry and occupation. This may cause some under estimation of the number of workers employed in certain industries or occupations, especially if they are jobs that are part-time or seasonal in nature. In addition, there may be certain occupations that are more difficult to assess using a household survey. For example, employment in the fishing industry may be under estimated by the CPS based

on an independent employment estimate for the State of Alaska in 1991 (Conway, 1994). Conway reported an annual average of 18,000 workers in the Alaska fishery in 1991, while the CPS reported an estimate of approximately 3300 workers for the same year. It is unclear whether this discrepancy in fishing employment only occurs in the State of Alaska, or is a common undercount in all States in the CPS. If this magnitude of under estimation does occur nationally, then the lifetime risks presented here for the fishing industry would be dramatically overestimated. The extent to which other occupations are under reported in the CPS is hard to document. Despite these limitations in the CPS, no other data source is available that allows for the calculation of employment by industry and occupation on an annual basis in the United States.

Finally, when examining the lifetime risks presented in this paper, it is important to remember that the risk estimates are for a population of individuals, not a single individual. In addition, the estimates rely on a pooled estimate of risk for all workers between the ages of 20 and 64 years. Thus, estimates for risk for an individual worker, or group of workers of differing ages are not addressed in this approach. While it would be possible to use this technique to define the risk of workers for a portion of their working life within a given industry and occupation, or to develop a risk estimate for an individual who moves through different jobs during a working lifetime, such an approach would not be practical when comparing occupations and industries, gender, or race. By making these comparisons based on a fixed set of criteria, these comparisons become more meaningful from a public health perspective.

CONCLUSIONS

The use of lifetime risk estimates in assessing the risk of traumatic fatal injuries to specific occupations employed within specific industries is a useful means for both prioritizing occupational injury concerns nationally, and in gauging the relative risks workers face from fatal injuries with respect to occupational health. The results of this work clearly show the usefulness of considering lifetime risk when defining the seriousness of a specific type of fatal event for a defined occupation within an industry.

The results presented here do show many consistencies with previous occupational fatality studies defining high-risk occupations or industries. This work, however, provides new insight on high-risk occupations within industries that, while understandable when looked at carefully, have not been clearly identified in previous literature. Lifetime risk estimates, such as those for male airplane pilots working in the agricultural services industry, strengthen the position that working lifetime risks to occupational fatal injuries pose a major public health threat for certain workers, and that fatal injury risk assessment is of equal importance to occupational health risk assessment when prioritizing ways of improving the health and safety of U.S. workers. Finally, these lifetime risk estimates may play a useful role in assisting the public health

community in notifying workers of their fatal injury risks in a similar fashion that workers are informed of occupational illness and disease risks.

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