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Occupational Injury Mortality Surveillance in the United States: An Examination of Census Counts From Two Different Surveillance Systems, 1992–1997

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Background *The surveillance of occupational injury mortality in the United States has evolved over the last century. Currently there are two different data sources used for the study of occupational injury mortality. Each system varies in methodology, leading to different census counts. We provide an overview and analysis of similarities and differences in these two systems.*
Methods *The National Traumatic Occupational Fatalities (NTOF) surveillance system and the Census of Fatal Occupational Injuries (CFOI) were examined for civilian deaths at work in the United States from 1992 to 1997.*
Results *There were 31,643 occupational injury mortality cases according to NTOF and 37,023 from CFOI for civilian workers 16-years and older in the United States for the 6-year period of analysis. The annual average occupational injury mortality rates were 4.5 per 100,000 full time equivalent workers from NTOF and 5.2 from CFOI. The higher capture rate by CFOI was consistent across each of the 6 years. Similar patterns for demographics, industry, and occupation, and type of incident were seen for both systems.*
Conclusions *While NTOF provides more years of data dating back to 1980, CFOI (established in 1992) provides a more comprehensive capture of occupational injury mortality and provides greater detail of the mortality incidents. The overall injury mortality patterns, however, appear to be similar between the systems.* Am. J. Ind. Med. 45:1–13, 2004. © *2003 Wiley-Liss, Inc.*

KEY WORDS: occupational; work-related; injury; mortality; surveillance

INTRODUCTION

The systematic surveillance of occupational injury mortality at the national level dates to the early parts of the twentieth century. Over the century, a number of injury surveillance systems have been utilized in efforts to estimate and characterize the magnitude of occupational injury mortality in the US. Even as late as the mid-1980s, great disparity existed in estimates of the magnitude of occupational injury mortality in the US. At the time, the Bureau of Labor Statistics (BLS) was using private sector data from a sample survey (the Survey of Occupational Injuries and Illnesses) to generate the annual estimate of 3,270 occupational injury and illness mortality cases in 1988 [Bureau of Labor Statistics, 1990]. The survey was not intended to be an all-encompassing national level injury mortality surveillance system, as the fatality data excluded workers in establishments with fewer than 11 employees, the self-employed, and workers in the public sector. The National Safety

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Council derived an estimate of 10,600 unintentional occupational injury mortality cases in 1988 using an in-house data base and national mortality data tapes obtained from the National Center for Health Statistics [National Safety Council, 1989].

The most problematic aspect of using the mortality data tapes for the study of occupational injury mortality is that although death certificates contain an item for Injury-At-Work, this variable was not automated (or encoded) in the mortality data tapes. To overcome this limitation, the National Safety Council used Place-Of-Occurrence as a proxy for the Injury-At-Work item. The National Safety Council selected cases that were classified as both (1) ''accidental'' death, and (2) that contained Place-Of-Occurrence data values thought best to define ''at-work'' cases. They also selected a percentage of the ''accidental'' deaths with the place of occurrence classified as ''unknown,'' assuming that part of these cases occurred at work. In addition, a percentage of the motor vehicle incidents were included, based on previous experience as to what proportion were thought to be work-related. It is these two methodologies of the BLS and National Safety Council that have historically been utilized most often. It is also these two methods that have provided the most strikingly different estimates of the magnitude of occupational injury mortality in the US.

A third method for estimating the magnitude of occupational injury mortality was published by the Office of Technology Assessment, in which they applied the occupational injury mortality rates derived from the BLS survey to the proportion of the workforce not covered by the survey's fatality estimates (e.g., the public sector, establishments with less than 11 employees, and the self-employed). After adjusting for heart attacks, they developed an average annual estimate of about 6,300 cases per year for the period 1980 through 1983 [Office of Technology Assessment, 1985]. A second but very similar method produced an average annual estimate of 6,180 for the same time period [Kronebusch, 1984].

In the mid-1980s, yet another methodology was developed for the study of occupational injury mortality. During this time, the National Institute for Occupational Safety and Health (NIOSH) began compiling a census of all death certificates for occupational injury mortality cases from the 50 states in a system referred to as the National Traumatic Occupational Fatalities (NTOF) surveillance system. The significant difference between the information collected by NIOSH compared to the mortality data tapes is that NIOSH collects copies of the death certificates from the states, not just the encoded information as is the case with the National Center for Health Statistics. This provides NIOSH with the ability to encode the Injury-At-Work item on the death certificate, along with narrative information for the job title and industry of the decedent, and the narrative text describing the injury incident. For the period 1980 through 1983, NIOSH reported the average annual number of occupational injury mortality cases to be 6,714 [Jenkins et al., 1993]. This estimate is similar to the estimate of 6,300 reported by Office of Technology Assessment, and the disparity between these estimates is much less than that of the BLS and National Safety Council. Another significant characteristic of the NTOF system was that for the first time, a national level surveillance system contained case-specific narrative text describing the injury incident and cause of death, thus providing information required for the study of etiological circumstances and causal factors of the injury incidents [Sorock et al., 1997; Stout, 1998].

Research started to appear in the literature during the mid-1980s that characterized weaknesses in the methods being utilized. Trent reported that using the Place-Of-Occurrence on death certificates to identify occupational injury mortality would only identify about 31% of the occupational cases, with a large number of occupational cases occurring in places not considered typical work settings (e.g., 28% of the positive cases were classified as Other Specified Places and 23% on a Street and Highway) [Trent, 1989]. In addition, there was not a standardized definition for the Injury At Work item on death certificates (until 1992), leading to subjective interpretation of each certifier as to whether the death was occupational. Two state-specific studies compiled occupational mortality information from a variety of different sources, including medical examiner reports, death certificates, workers' compensation claims, and occupational safety agencies. These two studies reported that death certificates alone would identify about two-thirds to three-quarters of all occupational mortality cases [Karlson and Baker, 1978; Baker et al., 1982]. In a multiple source comparison of the NTOF system, NIOSH personnel reported that use of death certificates alone under-reported the true magnitude by about one-fifth [Stout and Bell, 1991].

In 1987, a report entitled, Counting Injuries and Illnesses in the Workplace: Proposals for a Better System was published [National Research Council, 1987]. The National Research Council reviewed the various procedures used to produce the estimates of occupational injury mortality, describing the strengths and weaknesses of each approach, and made recommendations to improve the overall quality of surveillance in the US. This report recommended that a multiple source occupational injury mortality surveillance system be developed that captured all deaths, specifically:

> ''BLS should work with state agencies to carry out studies in which complete rosters of occupational fatalities are compiled from death certificates, medical examiner records, workers' compensation claims, and reports to OSHA and matched against OSHA 200 logs in the establishments in which these workers were employed'' (page 106).

Based on these recommendations, the BLS developed the Census of Fatal Occupational Injuries (CFOI). The CFOI surveillance system is a multiple source surveillance system containing narrative descriptions of the injury incident, which had been previously demonstrated as important in providing a mechanism for the analysis of causal factors. The first full year of CFOI data for the entire US was compiled for the year 1992. In 1992, BLS reported that death certificates accounted for 78% of all fatalities captured by CFOI, an estimate very close to that previously reported by NIOSH and a study conducted in Wisconsin [Karlson and Baker, 1978; Stout and Bell, 1991; Drudi, 1995].

The current state of occupational injury mortality in the US involves the continued use of both the NTOF and CFOI systems. BLS discontinued use of the private sector survey for fatality research as the CFOI system was implemented. The National Safety Council has adopted the use of CFOI data for their reporting, although they include only unintentional incidents, excluding deaths from intentional acts such as homicide at work. For research purposes, NIOSH analyzes data from both systems as each has advantages. This overview and analysis will help readers better understand the similarities and differences between these two systems and be in a better position to interpret and use the statistics.

METHODS

NTOF

The information in the NTOF surveillance system is compiled by NIOSH directly from death certificates collected from the 52 vital statistics reporting units, including the 50 states, New York City, and District of Columbia. Case inclusion criteria include:

(1) a positive response to the ''Injury at Work?'' item,
(2) 16 years of age or older, and
(3) an external cause of death (as classified by the International Classification of Diseases, Ninth Revision; E800–E999).

For coding the ''Injury at Work'' item, operational guidelines were developed and disseminated in 1992 (Appendix A–Part 1). The information collected for the NTOF files includes age, gender, race, cause of death, ''usual'' occupation and industry, and a 60-character narrative description of the injury incident. The NTOF system contains data starting with the year 1980. NTOF system includes both civilians and military personnel who died from work in the US. Deaths to civilian and military personnel occurring abroad are excluded.

CFOI

The information in CFOI is gathered for BLS by the states and includes data from a variety of sources, such as death certificates, workers' compensation claims, medical examiner reports, police reports, as well as the news media. Federal agencies that maintain injury surveillance data provide this information for inclusion in CFOI, including but not limited to the Occupational Safety and Health Administration, Employment Standards Administration, and Mine Safety and Health Administration. A requirement for case inclusion in the CFOI data is that information about work-relatedness be verified by two sources, or from a source document and follow-up questionnaire to the employer, person with knowledge of the incident, or the next-of-kin (if not prohibited by state law). Fatalities with only one source document are included if the state and BLS agree that information is sufficient to consider the death work-related.

The occupational, or at-work aspect of the definition used for CFOI is as follows:

A work relationship exists if an event or exposure results in a fatal injury to a person:

(1) ON the employer's premises and the person was there to work; or
(2) OFF the employer's premises and the person was there to work, or the event or exposure was related to the person's work or status as an employee.

The employer's premises include buildings, grounds, parking lots, and other facilities and property used in the conduct of business. Work is defined as duties, activities, or tasks that produce a product or result; that are done in exchange for money, goods, services, profit, or benefit; and, that are legal activities in the United States. Injury mortality involving transportation as part of the job, or on the employer's premises such as a parking lot, are included as an occupational injury. Mortality that occurs during the decedent's commute to and from work are excluded (see Appendix A–Part 2 for more information).

An ''injury'' in CFOI is defined as:

> ''. . . any intentional or unintentional wound or damage to the body resulting from acute exposure to energy, such as heat or electricity, or kinetic energy from a crash; or from the absences of such essentials as heat or oxygen caused by a specific event, incident, or series of events within a single workday or shift'' [Toscano and Windau, 1997].

Information in the CFOI system includes demographics such as age and sex, as well as industry of the employer, occupation of decedent, task or work activity, equipment involvement, injury event, and a narrative description of

incident. There is no minimum age for a case to be included in CFOI. The first year in which data were collected in CFOI for the entire US was 1992. Like the NTOF system, CFOI includes both civilians and military personnel who died from work while in the US, but excludes incidents occurring abroad.

Cause of Death/Type of Incident

The item for the cause of death, or type of incident, varies between NTOF and CFOI. In NTOF, the cause of death is coded according to the International Classification of Diseases, Ninth Revision supplementary chapter for the classification of external causes of injury and poisoning, using E-codes E800 through E999 [World Health Organization, 1977]. CFOI utilizes the injury event/exposure item from the Occupational Injury and Illness Classification System (OIICS) developed by BLS [Toscano et al., 1996]. The use of two different coding schemes makes direct comparisons between NTOF and CFOI difficult. For this analysis, five categories were chosen as they were previously identified as five of the top six causes of death, including homicide, struck by falling objects, falls, electrocution, and motor vehicles [Marsh and Layne, 2001]. Based on the author's familiarity with the two coding schemes, the categories of homicide and struck by falling objects should be compatible. Falls and electrocutions are similar but the E-codes for falls include the category ''E-887 fracture unspecified,'' that would most likely not be contained in the falls category of the OIICS event/exposure coding scheme. For electrocutions, the OIICS injury event/exposure category includes ''315 struck by lighting,'' this category is not included in electrocutions based on the E-codes. These apparent discrepancies were not corrected in the analysis and are displayed in the format consistent with usual reporting practices. The motor vehicles categories of the two coding schemes are not concordant relative to the previous comparisons (e.g., homicide, struck by falling objects, falls, and electrocution), but the comparison was included because motor vehicles are the leading cause of death in NTOF and leading injury event/exposure in CFOI. The machinery category (ranked third by using the E-codes [Marsh and Layne, 2001]) is excluded as no viable cross-classification could be constructed. Appendix B displays the coding rubrics for the comparison of the ICD-9 E-codes in NTOF and OIICS injury event/exposure of CFOI used in this analysis.

Industry and Occupation

NTOF contains the ''Usual'' (or ''Lifetime'') industry and occupation, describing the decedent's job that they held for the longest time during their life (as derived from the death certificate). The CFOI system includes these two items and also the industry and occupation of decedent ''At Time of Death.'' Although CFOI contains both Usual and At Time of Death job descriptors, over 50% of the cases are blank for the Usual industry and occupation. Therefore the Usual industry/occupation from NTOF and At Time of Death industry/occupation from CFOI are used for the analysis.

Analysis

The present analysis includes occupational injury mortality incidents for civilians 16-years of age or older that occurred in the US for 1992 through 1997. These estimates exclude: (1) US citizens who died abroad, as neither NTOF or CFOI capture events outside the US; (2) decedents less than 16 years of age (CFOI collects these cases but NTOF does not); and (3) military cases due to the lack of a methodology for calculating incident rates based on hours of exposure (or full-time equivalents).[1] There were a total of 32,366 cases in NTOF, of which 723 were classified as military, leaving 31,643 cases for civilians 16-years and older. For the analysis of CFOI, two separate files were utilized. The CFOI ''standard'' files exclude an item for the exact age of the decedent, including only an aggregated item for all decedents less than 20-years of age. Special research data files provided to NIOSH by BLS were used for the removal of victims less than 16-years of age. The standard CFOI files were used to calculate all estimates, then the number of decedents less than 16-years of age were removed from the totals. In the standard CFOI file, there were a total of 37,875 cases with 699 classified as military. An additional 153 cases (as identified by the special research files) were removed leaving a total of 37,023 civilians 16-years and older for analysis. One possible error that may occur using this methodology is the inclusion of a few deaths for cases less than 16-years because these special research files do not have data from New York City.[2]

Incident Rates

The occupational injury mortality rates, or risk estimates, are calculated using employment estimates derived from the Current Population Survey (CPS) monthly micro data files [Bureau of Labor Statistics, 1993–1998]. The injury rates are presented per 100,000 full-time equivalent (FTE) workers. The FTE were constructed using the item ''Hours worked last week?'' from the CPS interview. The CPS data files and the use of the hours worked item are discussed in detail elsewhere [Ruser, 1998].

[1] Active duty military are considered ''on duty'' 24-hr per day whereas the definitions for civilian occupational (or ''at work'') incidents are more restricted making comparisons difficult between the two.

[2] New York City confidentiality restrictions do not permit BLS to include data from their jurisdiction in the special research files provided to NIOSH.

RESULTS

The magnitude of occupational injury mortality in the US from 1992 through 1997 for civilians 16-years and older was 31,643 from NTOF and 37,023 from CFOI. The annual average occupational injury mortality rate was 4.5 per 100,000 FTE based on NTOF and 5.2 from CFOI (Table I). Both surveillance systems show the largest number of deaths were recorded in 1994, although the NTOF system shows the highest occupational injury mortality rate in 1995 (Table II). The percentage of cases reported by NTOF compared to the case count from CFOI ranged from a low of 83% in 1994 to a high of 88% in 1995 (Table II).

Males accounted for 93% and 92% of the deaths in NTOF and CFOI during the 6-year period. Workers 25–34 and 35–44 years accounted for the largest number of deaths (for both males and females) (Table I). Figure 1 shows the number of cases for women by age group and year as reported by the two systems. For women 16–44 years, the percentage of total cases reported by NTOF as compared to CFOI ranged from a low of 78% in 1992 to a high of 86% in 1997. The range for women 45+ years was from 74% in 1993 to 87% in 1997. Figure 2 shows that for men 16–44 years, the percentage of cases ranged from 84% in 1992 to 90% in 1996; and for men 45+ years, from 80% in 1994 to 88% in 1995. The occupational injury mortality rates increase with age and the proportion of workers classified as white or black were about the same in both systems (Table I).

Figure 3 displays the cause of death according to the International Classification of Disease E-codes used in NTOF and the OIICS injury event/exposure from CFOI. Both systems show the same rank order for the five categories displayed along with very similar percentages, other than for motor vehicle events. The discrepancy in motor vehicle cases as identified by the two systems was 4,471 cases. Additional analysis shows that 1,861 cases in CFOI were either tractors (n = 1,119) or construction/mining/agricultural (excluding tractors) equipment (n = 742) involved in off-road incidents. These cases would most likely be coded to the machinery category using the E-codes in NTOF, rather than transportation as in CFOI, thus reducing the discrepancy between the two systems by about 42%. As mentioned previously in

TABLE I. Demographic Characteristics—Magnitude and Risk of Occupational Injury Mortality for Civilians 16-Years and Older, NTOF and CFOI, United States 1992–1997

	NTOF 1992–1997			CFOI 1992–1997		
Demographics	**Number**	**Column percent**	**Rate[a]**	**Number**	**Column percent**	**Rate[a]**
Total	31,643	100.0	4.5	37,023	100.0	5.2
Male	29,251	92.4	7.6	34,082	92.1	8.9
16–19	708	2.2	3.8	808	2.2	4.4
20–24	2,210	7.0	5.7	2,582	7.0	6.6
25–34	6,726	21.3	6.6	7,754	20.9	7.6
35–44	7,389	23.4	7.0	8,510	23.0	8.1
45–54	5,863	18.5	8.1	6,841	18.5	9.4
55–64	3,905	12.3	10.9	4,648	12.6	13.0
65+	2,426	7.7	20.9	2,873	7.8	24.7
Female	2,388	7.5	0.7	2,941	7.9	0.9
16–19	78	0.2	0.4	87	0.2	0.5
20–24	218	0.7	0.6	251	0.7	0.7
25–34	570	1.8	0.7	702	1.9	0.9
35–44	618	2.0	0.7	785	2.1	0.9
45–54	470	1.5	0.8	605	1.6	1.0
55–64	265	0.8	0.9	332	0.9	1.3
65+	168	0.5	2.0	172	0.5	2.1
White	26,483	83.7	4.4	30,423	82.2	5.0
Male	24,551	77.6	7.4	28,089	75.9	8.4
Female	1,928	6.1	0.7	2,334	6.3	0.9
Black	3,566	11.3	4.8	3,918	10.6	5.3
Male	3,266	10.3	9.0	3,567	9.6	9.9
Female	300	0.9	0.8	351	0.9	0.9

Age groups do not add to the total due to missing information for the age item.
[a]Rate = deaths per 100,000 full-time equivalents.

TABLE II. Magnitude and Risk of Occupational Injury Mortality for Civilians 16-Years and Older by Year, NTOF, and CFOI, United States 1992–1997

	NTOF		CFOI	
Year	Number	Rate[a]	Number	Rate[a]
1992	5,030	4.5	6,038	5.4
1993	5,286	4.6	6,199	5.4
1994	5,406	4.6	6,503	5.6
1995	5,314	4.7	6,115	5.1
1996	5,322	4.4	6,056	5.0
1997	5,285	4.3	6,112	4.9
Total	31,643	4.5	37,023	5.2

[a]Rate = deaths per 100,000 full-time equivalents.

Methods, the coding of motor vehicle incidents is not similar between the two systems and caution must be observed in interpreting the results.

An examination of the industry sectors (Table III) and occupation divisions (Table IV) shows that the magnitude and mortality rates are markedly similar, even in light of two different items being compared (e.g., Usual compared to At Time of Death industry and occupation variables from NTOF and CFOI, respectively). By industry sector, both systems identified construction and transportation/communication/public utilities as having the largest number of deaths. The rank order of the injury mortality rates is the same for the top five industry sectors. The largest reporting difference is seen in agriculture/forestry/fishing, with CFOI reporting 4,883 (13% of the total in CFOI) deaths compared to NTOF with 3,429 (11% of the total in NTOF). It is of interest that NTOF reports more cases among older workers (45+) in the mining sector, even though it identifies about 86% of the total number of cases compared to CFOI. Similar patterns are seen in the distributions for the occupation divisions, with both systems identifying the same top four occupation divisions for number of deaths and injury mortality rates, although the occupation divisions occupying the rank order of the first and second place are reversed.

DISCUSSION

It was not until the mid-1980s that an accurate national level surveillance system for occupational injury mortality was developed. Although the NTOF system was a single source system, it was not based on a sample, restricted by the industry of the worker (e.g., private versus public sector, or self-employed), or the size of the establishment. NTOF also demonstrated the value of narrative text for the study of causal factors of the injury incident [Sorock et al., 1997; Stout, 1998] and provides data dating back to 1980. Based on a report from the National Research Council and previous experience with injury mortality surveillance systems, the BLS developed a comprehensive, multiple source surveillance system (CFOI) in 1992. The NTOF and CFOI are comprehensive surveillance systems for occupational injury mortality in the US. The CFOI system increased estimates of magnitude by about 20% with the advantage of using multiple sources of information, although the different definitions used in two systems could account for some differences in the estimates. Neither of these systems, however, include occupational injury deaths of US civilians killed outside of the country. One potential source of information that would provide a start to the enumeration of overseas mortality is the aggregation of death benefit records from private insurance carriers. To the author's knowledge,

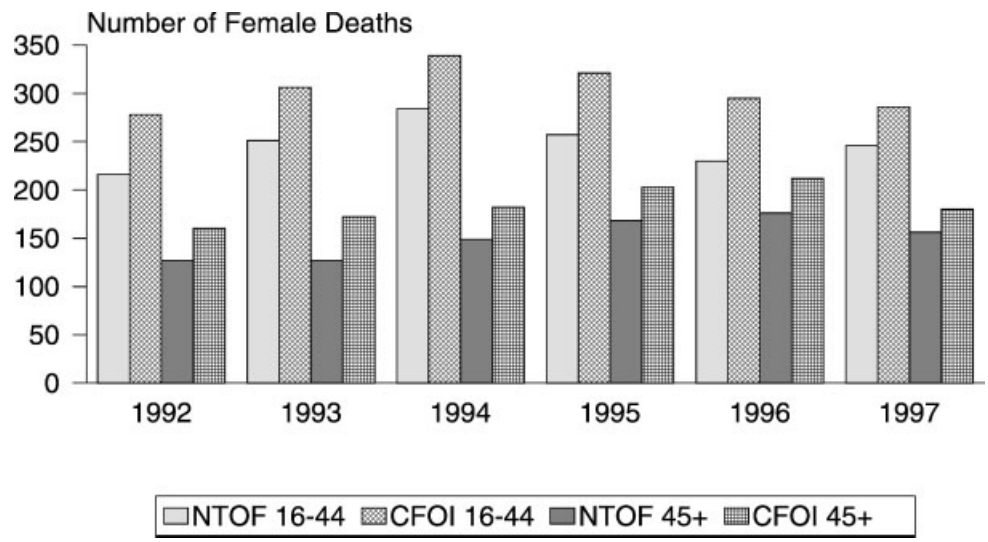

FIGURE 1. Magnitude of occupational injury mortality for women by age and year, civilians 16-years and older, NTOF and CFOI, US1992–1997.

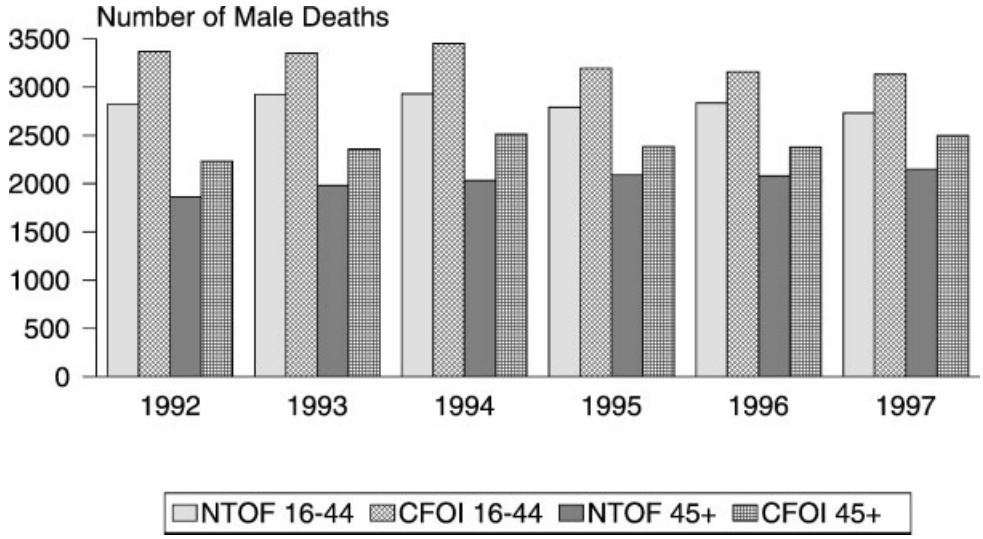

FIGURE 2. Magnitude of occupational injury mortality for men by age and year, civilians 16-years and older, NTOF and CFOI, US1992–1997.

however, there are not currently any estimates available pertaining to US civilian occupational injury mortality outside of the US.

The coding schemes used for external cause of death and type of incident differ between the two surveillance systems and makes some comparisons difficult if not impossible, while others are relatively straightforward. For example, mortality events involving homicide, falls, electrocutions, and struck by falling objects (four of the top six types of occupational injury mortality events [Marsh and Layne, 2001]) are fairly concordant whether using either the ICD-9 E-codes or the OIICS injury event/exposure codes (Appendix B). The distributions for these four types of mortality incidents were fairly comparable between the two systems. A large discrepancy in case counts for motor vehicles was identified. About 42% of the discrepancy was explained however, based on different coding rules. Additionally, it was previously reported that about one-third of the cases in CFOI (for the years 1992–1994) that were not present in NTOF were highway incidents [Biddle and Marsh,

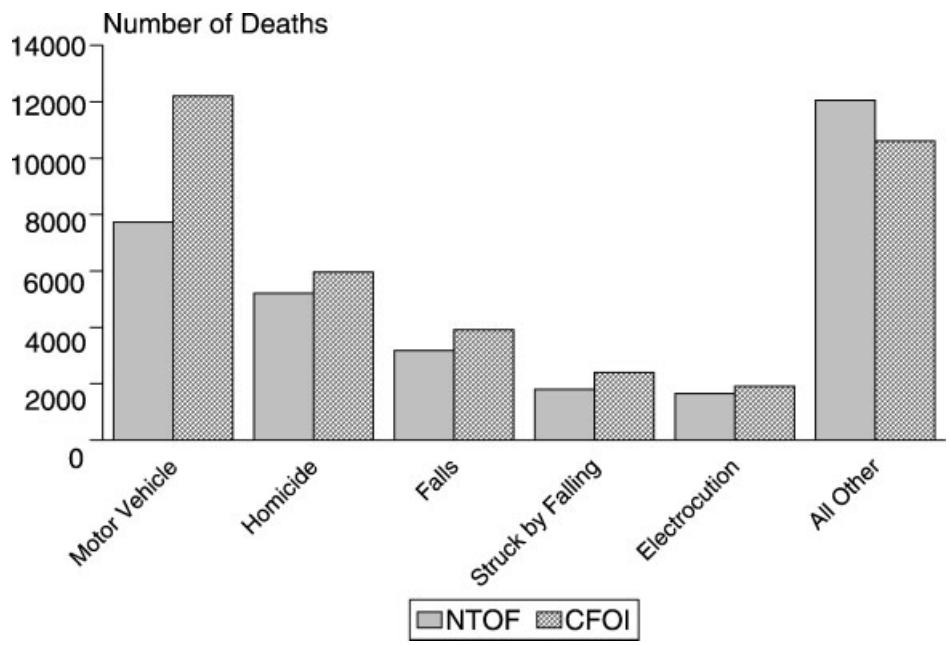

FIGURE 3. Cause of death (NTOF) and injury event (CFOI) for selected types of occupational injury mortality, civilians 16-years and older, US1992–1997 (see Appendix B for definitions of categories).

TABLE III. "Usual" (NTOF) and "At Time of Death" (CFOI) Industry Sectors by Age Group—Magnitude and Risk of Occupational Injury Mortality for Civilians 16-Years and Older, United States 1992–1997

	NTOF 1992–1997						CFOI 1992–1997					
	Total		16–44		45+		Total		16–44		45+	
Industry (SIC 1987)[a]	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Total	31,643	4.5	18,520	3.8	13,098	6.0	37,023	5.2	21,479	4.4	15,471	7.1
Agriculture, forest, fishing	3,429	17.2	1,627	13.0	1,799	24.5	4,883	24.5	2,080	16.6	2,795	38.0
Mining	966	26.8	630	25.5	335	29.5	1,003	27.8	681	27.6	322	28.3
Construction	5,781	13.3	3,700	11.7	2,080	17.6	6,334	14.5	4,184	13.2	2,143	18.1
Manufacturing	4,364	3.7	2,462	3.1	1,902	5.1	4,505	3.9	2,646	3.3	1,850	5.0
Transport, communication, public utilities	5,433	11.0	3,076	9.3	2,354	14.2	5,968	12.1	3,390	10.3	2,568	15.5
Wholesale trades	934	3.3	551	2.9	381	4.4	1,550	5.6	894	4.7	652	7.5
Retail trades	3,451	2.9	2,067	2.2	1,381	5.1	4,362	3.6	2,675	2.9	1,680	6.1
Finance, insurance, real estate	498	1.1	215	0.7	283	1.8	705	1.5	316	1.0	388	2.5
Services	3,865	1.6	2,246	1.4	1,618	2.0	5,102	2.1	3,001	1.8	2,091	2.6
Public administration	1,621	4.9	996	4.7	625	5.0	2,201	6.6	1,399	6.8	788	6.3
Unknown	1,301	n/a	950	n/a	340	n/a	410	n/a	213	n/a	194	n/a

Age groups do not add to the total due to missing information for the age item. Rate = deaths per 100,000 full-time equivalents.
[a]Standard Industry Classification Manual, 1987.

2002]. This provides support to previous research that has reported work-related transportation incidents are more difficult to identify through a single source death certificate surveillance system [Russell and Conroy, 1991].

The OIICS coding scheme has some advantages to analysts examining the data. The classification system was developed specifically for work-related injuries and illnesses. The OIICS coding system contains separate variables for the

TABLE IV. "Usual" (NTOF) and "At Time of Death" (CFOI) Occupation Divisions by Age Group—Magnitude and Risk of Occupational Injury Mortality for Civilians 16-Years and Older, United States 1992–1997

	NTOF 1992–1997						CFOI 1992–1997					
	Total		16–44		45+		Total		16–44		45+	
Occupation (BOC 1990[a])	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Total	31,643	4.5	18,520	3.8	13,098	6.0	37,023	5.2	21,479	4.4	15,471	7.1
Executive, administrator, manager	2,350	2.5	1,089	1.8	1,259	3.4	2,697	2.8	1,194	2.0	1,500	4.1
Professional specialties	1,441	1.5	748	1.2	693	2.0	1,575	1.6	872	1.3	702	2.0
Technician, related support	832	3.6	523	3.0	309	5.5	1,112	4.8	705	4.0	405	7.2
Sales	2,538	3.0	1,282	2.1	1,256	4.8	3,130	3.7	1,718	2.9	1,410	5.4
Clerical	687	0.6	375	0.5	311	0.9	722	0.7	426	0.6	295	0.9
Service	2,475	2.6	1,645	2.3	829	3.2	3,214	3.3	2,107	3.0	1,087	4.2
Farming, forestry, fishing	3,798	18.9	1,843	14.4	1,952	26.6	5,435	27.0	3,430	26.8	2,997	40.9
Precision production, craft, repair	6,319	8.1	3,908	7.1	2,408	10.5	6,501	8.4	4,153	7.6	2,344	10.2
Machine operator, assembler, inspector	1,486	3.3	942	3.0	544	4.3	1,372	3.1	877	2.7	494	3.9
Transportation, material mover	5,626	19.2	3,230	16.6	2,394	24.4	7,095	24.3	4,033	20.8	3,054	31.1
Handler, equipment cleaner, helper, laborer	3,116	11.0	2,187	9.5	925	18.0	3,748	13.3	2,715	11.8	1,031	20.1
Unknown	975	n/a	748	n/a	218	n/a	422	n/a	249	n/a	152	n/a

Age groups do not add to the total due to missing information for the age item. Rate = deaths per 100,000 full-time equivalents.
[a]Bureau of the Census Occupation Codes, 1990.

source which directly inflicted the injury, the injury event/exposure (which describes the manner in which the injury was produced), and a secondary source of injury—if applicable. Data are, therefore, available for fatalities involving specific types of equipment found at work (e.g., forklifts or tractors) as well as fatalities involving specific types of work-related incidents (e.g., vehicles overturning or pedestrians struck by a vehicle). Furthermore, these data are available either separately or in combination. For example, one can determine how many fatalities resulted from tractor overturns off of the roadway, as well as those on a highway. But the coding and interpretation are more complicated as multiple items (or variables) need to be taken into account. The E-codes concatenate all this information into a single code, making it relatively easy to use and understand, but this restricts the detail in which the data can be analyzed.

The OIICS coding scheme is also relatively new and may not be as well understood among public health professionals as the International Classification of Diseases E-codes. As well, the E-codes are standard on public health data sets such as mortality files. This provides a mechanism for comparing particular types of incidents such as work-related homicides to non-occupational homicides. Inclusion of the E-codes in the CFOI surveillance system could increase the efficacy and universality of these data, which would ultimately prove beneficial for intervention and prevention efforts. Additionally, adding the E-codes could be accomplished at a very low cost as shown with the NTOF system. NIOSH derives the E-codes by matching the NTOF data with that of the National Centers for Health Statistics mortality tapes (in which the E-codes have previously been automated) by using the death certificate identification number.

The differences in the industry and occupation items used in NTOF and CFOI lead to difficulties of interpretation that are more complicated than the issues surrounding the coding for the cause of death (as discussed above). Whereas problems for the cause of death focus on two different coding schemes used for enumerating the same item (what happened), the problems associated with comparing Usual and At Time of Death industry/occupation items are two prong, the first focusing on the fact that Usual and At Time of Death are separate indicators, and second, the data reliability of the items themselves.

The Usual and At Time of Death items are not the same indicators, and at times can be unrelated. For example, if a decedent was employed in manufacturing for the majority of his/her life but retired to farming and then was involved in a fatal farm event, the correct code for Usual industry would be manufacturing, while the code for At Time of Death would be agriculture/forestry/fishing. However, if the decedent had spent the longest time employed on a farm and the fatal incident also occurred on a farm, then coding for Usual and At Time of Death would be the same. It is important for public health professionals to recognize the difference between these industry and occupation items, particularly when etiologic factors are being attributed directly to the surrounding environment in which the incident occurred. For the study of illness, the industry and occupation that the decedent worked for the majority of their life might be most useful when attributing illness conditions to long term workplace exposures. But for injury, the etiologic factors of the immediate environment in which the incident occurred become the primary focus.

The collection and data enumeration (data reliability) of Usual industry/occupation on death certificates has been the focus of many studies (Appendix C). Appendix C includes the percentage for both exact coding matches and general category matches (if reported in the study). Industry sectors are reported according to the Standard Industrial Classification Manual, 1987, and occupation information according to the Bureau of the Census 1990 coding scheme [Office of Management and Budget, 1987; Bureau of the Census, 1990]. It has generally been found that death certificates for white and older workers with more years of work experience, or workers from well-defined industries and occupations are more reliable. What is missing from the literature is an industry/occupation reliability study that uses a large probability sample of all traumatic occupational mortality. Several studies have included a large sample but have relied on cancer surveillance systems or a synthesis of mortality studies (union or personnel records). Cancer surveillance is biased towards older workers (with age being related to longer work histories), this sample bias skews the results toward increased reliability. It has also been reported that workers from well-defined industrial groups bias results towards increased reliability [Steenland and Beaumont, 1984]. There are currently no studies that this author is aware of that have examined the reliability of the At Time of Death industry/occupation items as reported in CFOI.

Further examination of NTOF and CFOI to characterize the sensitivity, differences of the etiologic factors of the fatal incidents, and to explore variations in results between Usual and At Time of Death industry and occupation items of these two surveillance systems requires a matching technique to provide for direct case-by-case comparison. An initial effort to match the data has been undertaken with general discrepancies of unmatched cases illuminated [Biddle and Marsh, 2002].

The Future of Occupational Injury Mortality Research

Data from the CFOI system represent the latest public health accomplishments in the surveillance of occupational injury mortality. This surveillance system has played a key role in providing information for the targeting of jobs that present the highest injury mortality risk for additional research and intervention efforts. While this system represents

the latest in an evolution of occupational injury mortality surveillance many methodological issues remain unanswered. Future efforts should focus on obtaining better information on the circumstances leading up to a fatality, including the specific activities of the worker at the time of an injury incident. Improvements are also necessary in exposure (employment) data for the calculation of occupational injury mortality rates, particularly for special populations such as adolescents, migrant workers, and the aging workforce. An additional role for existing and future surveillance data are for use in the scientific evaluation of the efficacy of occupational injury mortality intervention and prevention efforts.

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APPENDIX A (Part 1)

TABLE A.1. Operational Guidelines for Determination of Injury at Work

	Injury at work	
NTOF criteria	**Yes**	**No**
On employer premises		
Engaged in work activity, apprentice, vocational training	✓	
On break, in hallways, rest room, cafeteria, storage area	✓	
In employer parking lots while working, arriving, or leaving	✓	
Engaged in recreational activities on employer controlled facilities (games, etc.) for personal enjoyment		✓
As a visitor for non-work purposes, not on official business		✓
Off employer premises		
Working for pay or compensation, including at home	✓	
Working as a volunteer EMS, firefighter, or law enforcement officer	✓	
Working in a family business, including family farm. Activity should be clearly related to a profit-oriented business.	✓	
Traveling on business, including to and from customer or business contacts	✓	
Engaged in work activity where vehicle is considered the work environment (e.g., taxi driver, truck driver, etc.)	✓	
Homemaker working at homemaking activities		✓
Working for self-non profit, i.e., mowing lawn, repairing own roof, hobby, or recreation activities		✓
Student engaged in school activities		✓
Operating vehicle (personal or commercial) for non-work purposes		✓
Commuting to or from work site		✓

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APPENDIX A (Part 2)

TABLE A.2. CFOI Work Relationship Criteria

A work relationship exists if an event or exposure results in a fatal injury or illness[a] to a person

(1) On the employer's premises and the person was there to work; or

(2) Off the employer's premises and the person was there to work, or the event or exposure was related to the person's work or status as an employee

The employer's premises include buildings, grounds, parking lots, and other facilities and property used in the conduct of business

Work is defined as duties, activities, or tasks that produce a product or result; that are done in exchange for money, goods, services, profit, or benefit; and, that are legal activities in the United States

The following are clarifications of the CFOI work relationship criteria

1. Volunteer workers who are exposed to the same work hazards and perform the same duties or functions as paid employees, and that meet the CFOI work relationship criteria, are in scope
2. Institutionalized persons, including inmates of penal and mental institutions, sanitariums, and homes for the aged, infirm, and needy are out of scope unless they are employed off the premises of their institutions
3. Suicides and homicides that meet the CFOI work relationship criteria are in scope
4. Fatal heart attacks and strokes are in scope, if they occurred on or off the employer's premises and the person was there to work. Those fatal heart attacks and strokes that occurred under other circumstances are out of scope, unless work relationship is verified[a]
5. Travel status: fatal events or exposures that occurred when a person was in travel status are in scope, if the travel was for work purposes or was a condition of employment. Clarification #6 (recreational activities) also applies to a person who was in travel status
6. Recreational activities: fatal events or exposures that occurred during a person's recreational activities, that were not required by the person's employer, are out of scope
7. Commuting: fatal events or exposures that occurred during a person's regular commute to or from work are out of scope

Source: fatal workplace injuries in 1997: A Collection of Data and Analysis, US Department of Labor, Bureau of Labor Statistics, Report 934, July 1999, p. 142.

[a]Information on work-related fatal illnesses are not reported in the BLS census counts.

APPENDIX B

TABLE B. Comparison of Coding Schemes for Selected Types of Incidents for ICD-9 E-codes (NTOF) and OIICS Event or Exposure (CFOI) as Utilized in Figure 2

	Classification scheme	
Type of incident	**ICD-9 E-codes**	**OIICS injury event**
Motor vehicle	E810–E819: MV traffic accident	41: Highway accident
	E820–E829: MV nontraffic accident	42: Nonhighway accident, except rail, air, water
	E846–E849: MV not elsewhere classified	43: Pedestrian, nonpassenger struck by vehicle, mobile equipment
Falls	E880–E888: Accidental falls	10–19: Falls
Struck by falling object	E916: Struck accidently by falling object	021: Struck by falling object
Electrocution	E925: Accident caused by electric current	310–319: Contact with electric current
Homicide	E960–E969: Homicide and injury purposely inflicted by other persons	610–619: Assaults and violent acts by person(s)

APPENDIX C

TABLE C. Reliability of Industry and Occupation on US Death Certificates Compared to Information Extracted From Personal Interviews, City Directories, Mortality Studies, and Medical Examiner Reports

Author(s); year pub	**Data source/ sample size**	**% Agreement**	**Comments**
Davis, 1988	Medical examiner	72% Industry	Homicide
	n = 533		Period 1975–1984
			Urban Texas counties
Gute and Fulton, 1985	Interview	57% Industry	Married
	n = 446	67% Ind Sector[a]	White only
		55% Occupation	Older population
		62% Occ division[b]	Residents of Providence, Rhode Island
	City directory	61% Industry	
	n = 322	73% Ind sector[a]	
		51% Occupation	
		59% Occ division[b]	
Roush et al., 1980	City directory	>95% Occupation	Connecticut cancer surveillance
	n = 459		Males only
			Period 1935–1975
			Detailed information about occupational coding and matching not provided
Schade and Swanson, 1988	Interview	62% Industry	Cancer surveillance
	n = 2,435	71% Ind sector[a]	Detroit metropolitan area
		48% Occupation	Period 1984–1987
		58% Occ division[b]	
Schumacher, 1986	Interview	67% Industry	Cancer surveillance
	n = 184	68% Occupation	Utah
			Period 1977–1981
			Over age 40
			White only
			Employed last 15 years (rather than "lifetime")
Steenland and Beaumont, 1984	Mortality studies	70% Industry	Personnel and union records from well-defined industries and occupations
	n = 2,198	65% Occupation	Long-term workers (10+ years; mean 18 years)
			Largely blue-collar cohorts

TABLE C. (*Continued*)

Author(s); year pub	Data source/ sample size	% Agreement	Comments
Swanson et al., 1984	Interview n = 352	76% Industry 76% Occupation	Cancer surveillance Detroit metropolitan area Period 1978–1980
Turner et al., 1987	Interview n = 87	72% Industry 54% Occupation	Cancer surveillance Utah Period 1978–1982 White only Male only

[a]Major industry sector.
[b]Major occupation division.