Denominator Effects on Traumatic Occupational Fatality Incidence Rates

RECAP

Fatality Rate Calculations

Each year over 6,000 workers are killed while earning a living in the United States. From these deaths, how can researchers determine if employees in the manufacturing industry are at greater risk of a traumatic occupational fatality than those employed in agriculture or any other industry? Similarly, does the risk of traumatic occupational fatality differ among states? To answer such questions, two measurements are normally used: *frequency of occurrence* and *incidence rate*. These measures are used to identify worker groups at greatest risk of fatal injury, target research and prevention activities, and evaluate the impact of these activities. Developing the best methods to accurately identify worker groups at greatest risk of losing their life while at work is always important, but even more so in times of limited government resources.

The accuracy of a traumatic occupational fatality incidence rate depends on how closely the denominator and numerator represent the same population. Selecting data from different employment programs for the denominator when calculating incidence rates using the *National Traumatic Occupational Fatalities* surveillance system for the numerator has shown dramatically different results. This analysis points out that researchers must **carefully**: choose the data they employ; evaluate the meaning of calculated incidence rates; and document the data sources to ensure proper interpretation by others. Additional research and evaluation are necessary to improve data sources, analytical methods and tools to ensure effective resource allocations for the occupational safety and health field. ■

Over 25 years ago, Congress passed the *Occupational Safety and Health Act*, which gave American workers the right to "safe and healthful working conditions."[1] This act created the National Institute for Occupational Safety and Health (NIOSH), which was charged with, in addition to other tasks, making recommendations for the prevention of work-related illnesses and injuries.

One of the programs NIOSH uses to gather information on fatal workplace injuries is the *National Traumatic Occupational Fatalities* (NTOF) surveillance system.[2] This program collects and automates demographic, employment and injury characteristics for workers who died as a result of a work-related injury. These injury statistics play a role in decreasing the number of fatal injuries by identifying worker groups at greatest risk of fatal injury, targeting research and prevention activities, and evaluating the impact of those activities.

However, because of the multitude of epidemiologic and demographic data sources available, it is important for researchers and policymakers to evaluate the quality of the data and statistical manipulations as well as the appropriateness of the comparison groups used for analyses and rate calculations before drawing conclusions and advocating actions.

The risk of occupational death among worker groups can be described by employing two measures—the frequency of occurrence and an incidence rate. These two separate but related measures are required to properly portray the state of workplace safety and health. The *frequency of occurrence* indicates the number of actual fatalities and its accuracy depends predominately on the quality of the survey design and methods. The *incidence rate* is the number of fatalities that

occurred within a given group over a specified period of time, divided by the number of workers (or hours of worker exposure) within that group and time period. The precision of the incidence rate is a function of the accuracy of the numerator and the denominator and the degree to which these two factors represent the same population.

The following examines a method used by NIOSH to calculate traumatic occupational fatality incidence rates (henceforth referenced as incidence rates) using the NTOF data and how different sources of employment data can affect incidence rates. Suggestions for adjusting or supplementing data sources to improve incidence rate accuracy are also presented.

Incidence Rates

Incidence rates are the number of fatalities divided by some measure of worker exposure. The ideal measure of exposure is the time a worker is exposed to some specific condition or risk factor associated with traumatic occupational fatal injuries. However, the time of exposure is not currently captured by NTOF (nor any other program) and is very difficult to estimate. Because of this limitation, the measures most commonly used by safety and health researchers are employment hours or number of workers. Using NTOF data as the numerator, NIOSH traditionally has used data sources reporting number of workers as the denominator in incidence rate calculations, producing rates per 100,000 workers.

Number of Fatalities (Numerator)

The number of occupational fatalities was obtained from the NTOF surveillance system for the years 1980 through 1989. These data were obtained from death certificates from 52 vital statistics reporting units (the 50 states, New York City and the District of Columbia). To be included, each death

Table 1—Selected Characteristics from the National Traumatic Occupational Fatalities (NTOF) Surveillance System, County Business Patterns (CBP) Survey and the Current Population Survey (CPS) United States, 1980-1989

Characteristics	NTOF	CBP	CPS
≥16 years of age	✔	✔	✔
Self-employed	✔		✔
Private households	✔		✔
Agricultural production	✔		✔
Agricultural services	✔	✔	✔
Railroads	✔		✔
Government-class of worker	✔		✔
Industry of worker	✔	✔	✔

Table 2—Average Annual Traumatic Occupational Fatality Incidence Rates by Year, United States, 1980-1989

Year of Death	CPS*	CBP†
	(Rate per 100,000 Workers)	
1980	7.5	8.9
1981	7.1	8.6
1982	6.5	7.8
1983	5.8	7.2
1984	5.9	7.1
1985	5.8	7.0
1986	5.2	6.1
1987	5.2	6.2
1988	5.0	5.9
1989	4.9	5.6
Average Annual Rate	5.8	7.0

*CPS = *Current Population Survey*. Rates were calculated using counts from the *National Traumatic Occupational Fatalities* (NTOF) surveillance system for the numerator and counts from the *Current Population Survey* (CPS) for the denominator.
†CBP = *County Business Patterns*. Rates were calculated using counts from the NTOF surveillance system for the numerator and counts from the *County Business Patterns* (CBP) for the denominator.

certificate must meet the following criteria: age 16 or older, have an *external* cause of death* (codes E800-E999)[3] and the injury at work item marked "yes." This includes full-time, part-time, government, selected volunteers and self-employed workers (Table 1). The data for this study are for the civilian population only. The industry where the worker was usually employed is categorized using the *1987 Standard Industrial Classification* (SIC) system.[4]

*"Classification of environmental events, circumstances, and conditions as the cause of injury, poisoning, and other adverse effects."

Number of Workers (Denominator)

Two broad categories of employment estimates are available for computing fatality incidence rates—establishment- and population-based data. Establishment-based data count *jobs* held with businesses, while population-based data count *workers* employed during the reference period. These two categories differ because of variations in collection methods, scope, definitions and coverage as defined by the survey or program. Examples of establishment-based data include *County Business Patterns* (CBP) from the Bureau of the Census, the *Current Establishment Survey* from the Bureau of Labor Statistics and the *Economic Census*

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Program from the Bureau of the Census. Examples of population-based data include the *Labor Force Statistics* and *Local Area Unemployment Statistics* from the Bureau of Labor Statistics, the decennial and special industry censuses conducted by the Bureau of the Census and the *Current Population Survey* (CPS) conducted by the Bureau of the Census for the Bureau of Labor Statistics. The following analyses use CBP and CPS program data as the denominators for the fatality incidence rates.[5,6]

The CBP is an annual program that collects information from states, counties and Puerto Rico, representing types of employment covered by the *Federal Insurance Contributions Act* (FICA). These data exclude agricultural production workers, domestic-service workers, railroad

Table 3—Traumatic Occupational Fatality Incidence Rates by Industry Division United States, 1980-1989

Industry Division	CPS*	CBP*
	(Rate per 100,000 Workers)	
Agriculture/Forestry/Fishing	21.8	18.3
Mining	32.5	31.9
Construction	16.9	25.6
Manufacturing	4.1	4.4
Transportation/Communication/Public Utilities	15.5	23.3
Wholesale Trade	3.1	2.4
Retail Trade	2.7	2.9
Finance/Insurance/Real Estate	1.2	1.4
Services	1.8	2.8

*CPS = *Current Population Survey;* CBP = *County Business Patterns.*
Note: See Table 2 for rate calculation method and sources.

workers subject to the *Railroad Retirement Act*, employment on oceangoing vessels or in foreign countries, most government workers and the self-employed (Table 1). To supplement this survey with agricultural production data and to create an agriculture division total, numbers from a Bureau of the Census agricultural program were employed,[7] classified by industry as defined by the 1987 SIC system.

Use of employment data excluding self-employed workers introduces a bias in the calculation of industry-specific incidence rates.

The CPS is a monthly household survey of the noninstitutional population 16 years of age and older for wage and salaried, self-employed and all agricultural workers (Table 1). Industry classification was based on the Census Bureau's *1980 Census of Population: Alphabetic Index of Industries and Occupations.*[8]

Results

In the United States more than 6,000 workers are killed annually while earning a living. From 1980 through 1989, the CBP-based annual average incidence rate was 7.0 per 100,000 workers compared with the CPS-based average rate of 5.8 per 100,000 workers (Table 2). Throughout this period, the CBP-based incidence rates were consistently higher than the CPS-based incidence rates. The CBP-based rates ranged from 8.9 in 1980

to 5.6 per 100,000 workers in 1989, while the CPS-based rates ranged from 7.5 to 4.9 per 100,000 workers in 1980 and 1989, respectively.

Table 3 compares industry division incidence rates calculated with the CBP data with those calculated with the CPS data. Over the 10-year period, the majority of the differences were not large. However, substantial differences were exhibited between the CBP- and CPS-based incidence rates for the construction and transportation/communications/public utilities industry divisions. The CBP-based incidence rates for both of these industry divisions were 1.5 times higher than the CPS-based rates.

Incidence rates using CBP and CPS data for selected industry divisions, by external causes of death, varied considerably (Table 4). For example, the CBP-based incidence rate for motor vehicle-related deaths in the transportation/ communications/public utilities industry was 1.5 times higher than the CPS-based incidence rate (11.4 versus 7.6 per 100,000 workers).

The same type of incidence rate calculations for selected states of workers' deaths show higher CBP-based incidence rates than CPS-based rates in nearly all instances (Table 5). However, the higher rate was never greater than 1.5 times the lower rate.

Best-Fit Denominator

When calculating traumatic occupational fatality incidence rates, numerator and denominator data sources need to be carefully matched to assure that both data sources represent the same worker population. In a time of limited resources for occupational safety and health, it becomes even more important to develop the best methods to accurately identify worker groups at greatest risk.

Table 4—Traumatic Occupational Fatality Incidence Rates by Selected Industry Division and External Cause of Death Combinations United States, 1980-1989

Cause of Death	Industry Division							
	Agriculture/ Forestry/Fishing		Construction		Transportation/ Communication/ Public Utilities		Services	
	CPS*	CBP*	CPS	CBP	CPS	CBP	CPS	CBP
	(Rate per 100,000 Workers)							
Motor Vehicle	3.43	2.88	2.46	3.72	7.61	11.44	0.35	0.54
Machine	7.47	6.28	2.31	3.50	0.83	1.24	0.12	0.19
Homicide	0.67	0.57	0.43	0.65	0.98	1.47	0.40	0.61
Fall	1.07	0.90	4.34	6.56	0.56	0.85	0.18	0.26
Electrocution	1.43	1.20	2.64	3.99	0.96	1.45	0.09	0.14
Struck by Falling Object	1.57	1.32	1.29	1.95	0.47	0.70	0.08	0.13
Air Transport	0.52	0.52	0.12	0.18	1.33	2.00	0.10	0.15
Suicide	0.49	0.41	0.24	0.36	0.19	0.29	0.15	0.23

*CPS = *Current Population Survey*; CBP = *County Business Patterns*.
Note: See Table 2 for rate calculation method and sources.

Decision makers frequently use rank ordering of these risks for setting policies allocating scarce resources. Choosing the "best-fit" denominator can result in a more efficient use of current resources by helping to better target research priorities and prevention efforts.

Various differences in the employment data sources influence the accuracy of the NTOF incidence rates. These factors are primarily associated with survey design, definition of "employed" and the data collection methods of individual programs. The following illustrates the influence that some of these factors exert

Researchers must carefully choose the data they use, carefully evaluate the calculated rates and carefully document data sources to ensure correct interpretation by others.

on incidence rates calculated using different data sources. Because these factors act either independently or collectively, explanations of the variation between incidence rates can be complicated.

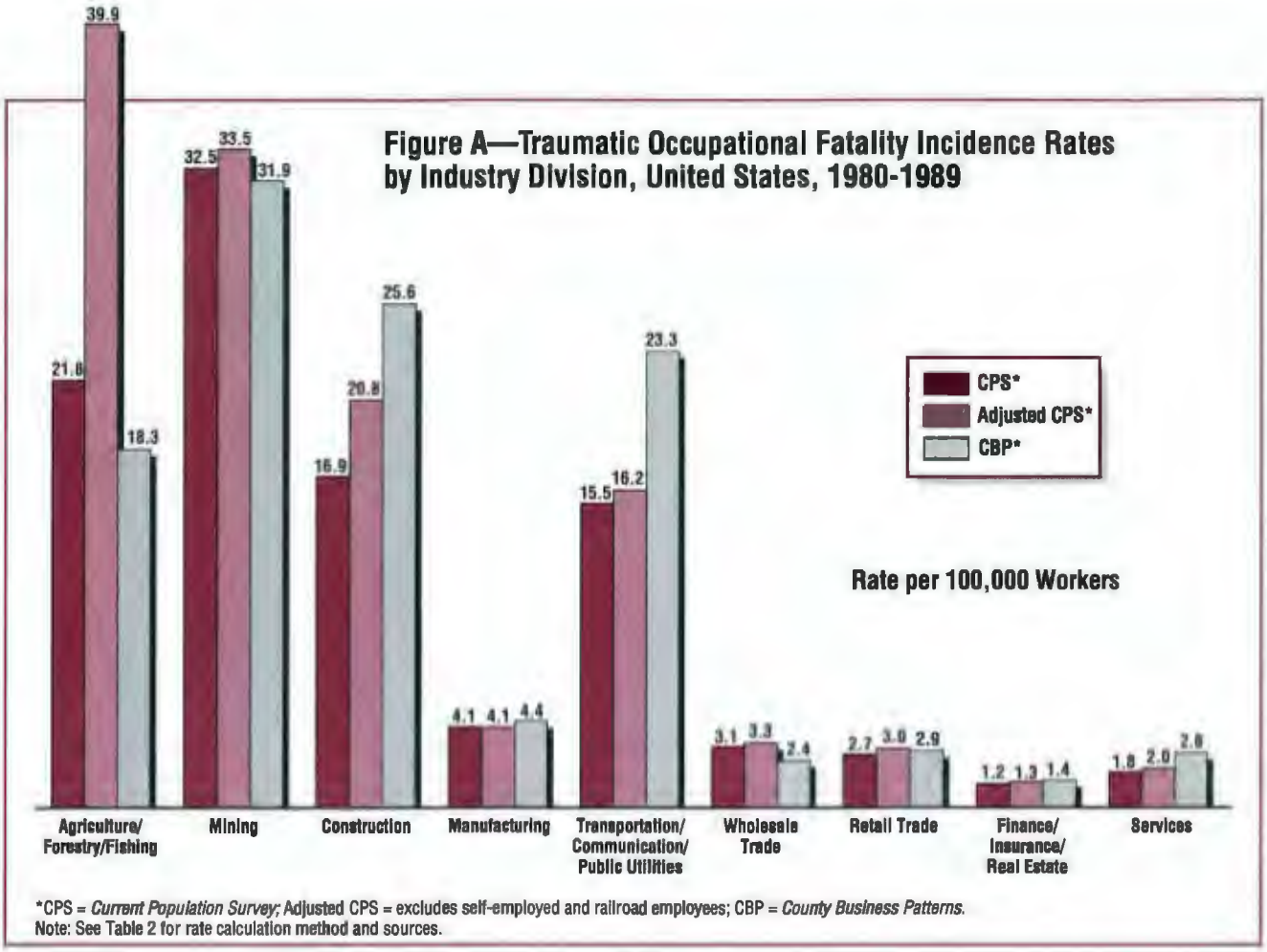
Use of employment data excluding self-employed workers introduces a bias in the calculation of industry-specific incidence rates, resulting in artificially high rates. As an example, construction industries tend to have high proportions of self-employed workers compared with other industry divisions. Thus, the incidence rates calculated using CBP data (which excludes the self-employed) are about 1.5 times greater than those computed using CPS data. The influence of this single factor is evident when the CPS data are adjusted by extracting the self-employed and the rates recalculated (Figure A). Using the adjusted CPS data, incidence rates in construction increased from 16.9 to 20.8 per 100,000 workers.

After the CPS data were reduced by the number of self-employed within agriculture, the magnitude of the difference between the incidence rates calculated based on the two data sources increased dramatically. This result suggests that another factor or factors are influencing the rates. One such factor is the exclusion of agricultural production employment counts from CBP. As mentioned, this survey was supplemented with agricultural production data from a Bureau of the Census agricultural program. In the late 1980s, the Division

Table 5—Traumatic Occupational Fatality Incidence Rates for Selected States United States, 1980-1989

State of Death	CPS*	CBP*
	(Rate per 100,000 Workers)	
Alabama	7.1	9.2
California	5.5	6.3
District of Columbia	6.4	4.5
Idaho	12.3	16.7
Kansas	6.7	8.6
Massachusetts	2.2	2.3
Michigan	4.1	5.1
Nevada	10.6	10.8
New York	2.3	2.6
Oklahoma	6.3	8.6
South Carolina	5.5	6.8
Texas	9.2	11.3
West Virginia	11.5	15.7
Wyoming	19.8	29.0

*CPS = *Current Population Survey*; CBP = *County Business Patterns*.
Note: See Table 2 for rate calculation method and sources.



*CPS = *Current Population Survey;* Adjusted CPS = excludes self-employed and railroad employees; CBP = *County Business Patterns.*
Note: See Table 2 for rate calculation method and sources.

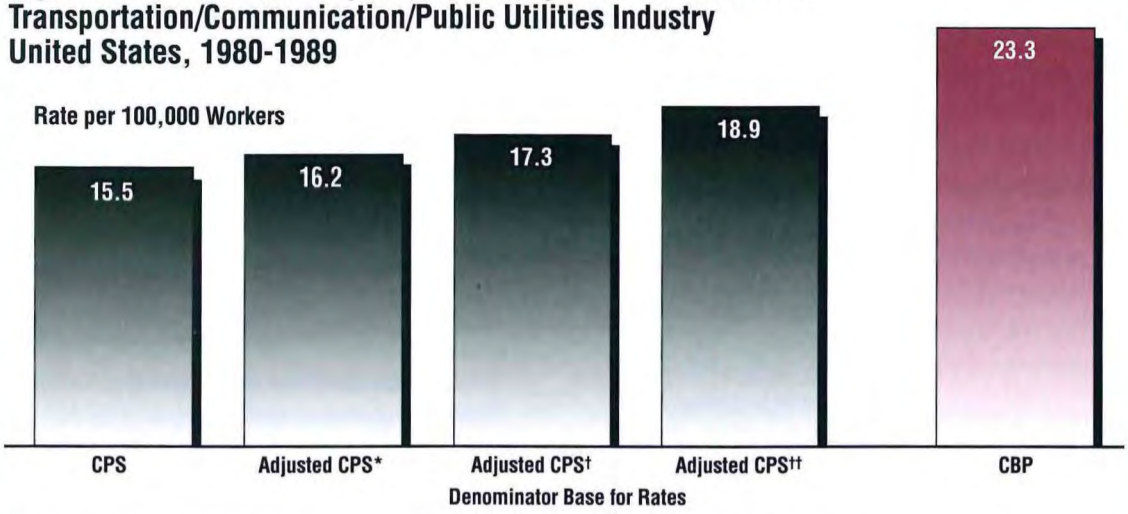
of Safety Research within NIOSH developed an algorithm to approximate the agricultural production count based on the *1982 Census of Agriculture*.[7] The employment numbers for agricultural production were estimated as follows:

$$\frac{\text{Census of Agriculture production data}_{1982}}{\text{CBP agricultural services data}_{1982}} = \frac{X_{\text{reference yr.}}}{\text{CBP agricultural services data}_{\text{reference yr.}}}$$

This model proved to be relatively accurate during the first few years. However, in later years, the agriculture division count was artificially high because the formula did not account for increases in agricultural services employment, which far exceeded increases in agricultural production employment. In addition, the *Census of Agriculture*, conducted every five years, did not produce agricultural production employment numbers for 1987 and 1992. Creating a benchmark, or a reference point, therefore, was not possible. Because of these limitations, incidence rate calculations have shifted toward using CPS employment numbers in recent years.

A similar situation exists in the transportation/communications/public utilities industry

Figure B—Traumatic Occupational Fatality Incidence Rates for Transportation/Communication/Public Utilities Industry United States, 1980-1989



CPS = *Current Population Survey;* CBP = *County Business Patterns.*
Note: See Table 2 for rate calculation method and sources.

* Excludes self-employed.
† Excludes self-employed and railroad employees.
†† Excludes self-employed and railroad and postal employees.

division. Using the CBP data inflates the fatality incidence rates for this industry because it excludes the self-employed and railroad employees. Again the incidence rate variation is notable, 1.5 times greater than the rate using the CPS data base. After adjusting the CPS data by excluding these worker groups, the magnitude of the difference decreased slightly. The exclusion of postal workers from the CBP data is another contributing factor to the rate differences. To complicate the situation further, in the first three years of the study, these employees were included in another industry division, public administration, in the CPS data. Recalculation of incidence rates to adjust for this additional difference, further reduced the differences in rates (Figure B).

Differences such as these are responsible for a portion of the variation in state specific incidence rates (Table 5). The distribution of industry within a state is another source of variation. For example, the difference between CBP- and CPS-based incidence rates would be greater in a state where construction represents a higher proportion of the total employment than in a state where construction accounts for a smaller proportion.

Although we have identified some factors contributing to these differences, further research is required to quantify the exact contribution of each variable and to identify other contributing factors.

Options

How do we improve the components of traumatic occupational fatality incidence rate calculations to accurately identify those worker groups at greatest risk to lose their life while at work? The best option is to collect the hours of exposure or employment data within the survey or census that counts

fatalities (in this case, NTOF). Unfortunately, this option is not always feasible—economically or methodologically.

A second option is to adjust the numerator to match the denominator or similarly adjust the denominator to match the numerator. When producing the incidence rates by industry for the 1993 NIOSH publication,[9] several sources were used to arrive at employment data that seemed most appropriate. These employment data were derived using CBP data supplemented with the *1982 Census of Agriculture* and the public administration data from the CPS. Since then, further research has suggested that using CPS data for incidence rate calculations would improve the match with the NTOF data. Information from this study confirms that hypothesis. At this time, CPS best matches the worker population included in the NTOF. Should either program change methods, scope or design, it would be imperative to reevaluate the quality of the match.

When calculating incidence rates using other data sources for the numerator, it is often difficult to find a perfect match between the population it represents and the population represented by available employment estimates. Where a perfect match cannot be made, the researcher must consider how the mismatch affects the resulting incidence rate. For this reason, readers, as well as researchers, are cautioned to examine fully the nuances of each data source to appropriately interpret results. ■

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STATISTICAL BULLETIN

VOL 79 NO 1 JAN-MAR 1998

MetLife®