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Assessing Data Sources for State-Level Occupational Fatality Rates: Oregon, 2003–2007

Terry R. Hammond, MPH,* Gary Rischitelli, MD, JD, MPH, and Erika Zoller, MPH

Background *This study assesses state-level data sources for numerators and denominators in occupational fatality rates. Data from Oregon Fatality Assessment and Control Evaluation, 2003–2007, are used to assess numerators, and to produce fatality rates using different data sources for denominators.*
Methods *Data sources for state-level occupational fatalities and the employed population are described. A statistical test for interrater reliability is applied in the comparison to Census of Fatal Occupational Injuries data. Odds ratios are calculated in the presentation of incident rates by age.*
Results *Comparison of occupational fatality data sources demonstrates substantial differences. Acquiring appropriate state-level denominator data are limited, particularly for stratified groups.*
Conclusions *Although not decisive, occupational fatality rates may help confirm areas of concern to guide necessary field work. This assessment of data sources and identification of several priority areas of concern in Oregon may help state researchers direct their own efforts to target priorities for effective interventions.* Am. J. Ind. Med. 55:332–343, 2012.

KEY WORDS: occupational fatality rates; numerator data; denominator data; risk assessment; state-level epidemiology; United States population surveys

INTRODUCTION

Oregon Fatality Assessment and Control Evaluation (FACE) began collecting data on traumatic occupational fatalities in 2003, and now has 5 years of data to evaluate patterns of incidence. Oregon FACE charts annual incident frequencies by demographic characteristics and codes for industry (NAICS), occupation (SOC), and event (OIICS); and reports incident rates for the overall working population in the state and by county. The small number of occupational fatalities at the state level makes inferences from a single year unreliable, particularly for subdivisions in the population, and the present accumulation of data—352 fatalities in 321 incidents—presents an opportunity to assess trends with greater confidence.

Assessing comparative frequencies of events over time or between groups is a common and useful method for defining areas of concern. Simple frequencies, though, lack a reference to an underlying exposure to a risk factor. Rates are preferable as a valid measure of risk—even rough rates, such as detecting a disproportionately high number of incidents among a small population of workers or with a low level of exposure.

Precision in occupational fatality rates is difficult to achieve, particularly with data available at the state level. A Health Resources and Services Administration report [2004] provides a good summary of primary national datasets and the limitations for state-level use to target specific

Oregon Fatality Assessment and Control Evaluation, Center for Research on Occupational and Environmental Toxicology, Oregon Health & Science University, Portland, Oregon
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*Correspondence to: Terry R. Hammond, MPH, 7624 SE Hawthorne Blvd, Portland, OR 97215. E-mail: terryh@pdx.edu

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occupations. The study found numerous obstacles; research informants from four states indicated a lack of consistency in data used and expertise in evaluating appropriate use. A survey of state capacity in epidemiology, conducted by the Council of State and Territorial Epidemiologists (CSTE) in 2001 [Boulton et al., 2006], found low capacity and training in all areas except infectious disease.

Considering the difficulties involved with the selection of data to produce meaningful occupational fatality rates, this report on incidents in Oregon for the 5-year period, 2003–2007, assesses data sources currently available to track occupational fatalities (numerators), and the working population (denominators), and calculates fatality rates as the data allow to distinguish areas of concern. Along with a presentation of results for occupational fatalities in Oregon, the purpose is to make data sources more familiar, and their strengths and weaknesses more explicit.

MATERIALS AND METHODS

Following are descriptions of the data sources used to obtain numerators and denominators for state-level occupational fatality rates. Methods used to assess the different data sources are then described. All numerator comparisons and rate calculations use Oregon FACE data in the 5-year period, 2003–2007.

Numerators

The most common numerators in occupational fatality rates use data from death certificates, Workers' Compensation, the Census of Fatal Occupational Injuries (CFOI), or FACE. Workers' Compensation counts incidents only for those workers covered by state Workers' Compensation insurance; the other sources count incidents for all workers.

Death certificates

State of Oregon Vital Records now manages death certificates with an electronic system, and the database may be queried to obtain death certificates identified as ''injury at work.'' Death certificates usually report the place of injury, which may be different from the state where the death occurred and the death certificate was issued. Oregon FACE currently relies on news alerts and other sources as well as death certificates to confirm cases.

Workers' Compensation

With official links to Oregon OSHA and state data and coding systems, Workers' Compensation (WC) records are a common source for studies and news on state-level occupational fatalities [McCall et al., 2007; Walters et al., 2010]. A significant number of workers are not covered by the Oregon Workers' Compensation system, including government and household employees, contractors, casual laborers, corporate officers, self-employed workers, and others, encompassing by definition many truck drivers, agriculture, forestry, and fishing workers (full itemization available in Oregon Revised Statutes 656.027). Coverage by Workers' Compensation defines the scope of Oregon OSHA's ''program-related'' fatalities. Workers' Compensation counts incidents involving covered Oregon workers that occur in other states, while Oregon OSHA counts only the subset of incidents that occur within Oregon.

Census of Fatal Occupational Injuries

CFOI operates in all states, and began surveillance of occupational fatalities in Oregon in 1991, through the Oregon Department of Consumer and Business Services, Information Management Division. CFOI tracks all fatal occupational injuries that occur within a state's boundaries, regardless of the worker's state of employment or regulatory coverage. Inclusion criteria and surveillance procedures for CFOI and FACE are parallel.

Fatality Assessment and Control Evaluation

State FACE programs are a project of the National Institute for Occupational Safety and Health (NIOSH), designed to conduct surveillance, investigation, and assessment of traumatic occupational fatalities, and to produce safety materials and interventions to promote worker safety [Higgins et al., 2001]. Nine states currently participate. Three inclusion criteria are applied to each potential incident to determine that it (a) occurred within state boundaries, (b) was a traumatic injury, and (c) occurred at work. Although the criteria are simple, a surprising degree of interpretation is often required. Oregon FACE added port of origin, for example, as a factor to decide inclusion of water transportation incidents in the Columbia River (dividing Oregon and Washington) or marine incidents beyond the state territorial limit. In regard to traumatic injuries, examination of medical examiner and police reports may be necessary to determine if a medical condition, usually excluded, combined with a work-related causal factor or activity to determine the fatal result. The ''at work'' designation is the most problematic, with uncertainty arising most commonly when determining if a motor vehicle incident occurred as a commute (excluded) or as a work routine; or if a rural incident occurred as a farm work activity or a private avocation; or if an act of violence apparently related to work should be included if it occurred away from the worksite. Information collected for each case file assists with surveillance inclusion

criteria and the assessment of risk factors, including the death certificate, medical examiner and police reports, news stories, hospital or first responder records if necessary, and reports from Oregon OSHA and other agencies when available. In some cases, personal communication must be initiated with a local sheriff or other knowledgeable person to obtain sufficient information on work status or details of the event.

Denominators

Several national data sources support estimates of employment, hours worked, and classification by industry, occupation, and demographic characteristics. Due to inadequate survey coverage, not all of these data are available for use at the state level. Nearly all denominators in occupational fatality rates refer to workers, either as the number of persons employed or hours-based full-time equivalent workers. In particular settings, it might be possible and more accurate to use denominators that refer to production level, miles traveled, or use of materials [Blank et al., 1998; Jagger, 2002].

No single data source provides an adequate denominator for every purpose. The sources used here for particular applications include the U.S. Census, BLS Local Area Unemployment Statistics (LAUS), and BLS Occupational Employment Statistics. The Current Population Survey and the Oregon Labor Market Information System are also discussed.

U.S. Census

The U.S. Census, with annual updates by the American Community Survey, provides state-level employment data by 2-digit NAICS industry codes, and a selection of generalized occupation codes. The Census is particularly helpful in measuring the proportion of self-employed workers in each industry, which can then be applied to correct state data that counts only employed workers covered by Workers' Compensation. The Census also provides state-level data on demographic characteristics of the working population. One study [Richardson et al., 2004] that compared Census and Current Population Survey (CPS) data showed a very close correspondence between the two datasets at the national level, indicating that Census data at the state level may be reliably extrapolated over the 10-year interval between censuses for use in denominators. The Census recorded higher error, however, for outdoor work – as in agriculture, forestry, fishing, and construction – due to high seasonal variation in the workforce, which the Census missed. The American Community Survey (ACS) supplements the Census with 1-year population estimates, and since 2005, made available improved 3-year and 5-year estimates. As ACS data gains prominence as a supplement or possible replacement for the Census, assurances for ACS accuracy by Bureau of the Census analysts [Griffin et al., 2003] is countered by a degree of caution by state analysts [Blodgett, 2009; Krumenauer, 2010], concerned about the small sample size and exclusion of small-area populations.

Current Population Survey

CPS data includes all workers, including the self-employed, as well as demographic variables, hours worked, and a wealth of other work-related information. Although published studies often use CPS data at the state level, CPS statistics are only sound at the national level—as the survey's methods explicitly warn: ''Although the present CPS sample is a State-based design, the sample size of the CPS is sufficient to produce reliable monthly estimates at the national level only'' [Bureau of Labor Statistics, 2008, p. 10]. CFOI does not report fatality rates at the state level with CPS denominators as it does at the national level. CPS population estimates at the state level must be expected to be highly unreliable, particularly for subdivisions in the population related to demographic characteristics or coding by industry or occupation [Bena et al., 2004]. Unfortunately, worker categories in the Census are limited, and the many variables in CPS are tempting to use. The Council of State and Territorial Epidemiologists [2004] produced a how-to booklet for state analysts to compute incident rates using CPS micro data for denominators. In one among many examples, a Washington state study extrapolated Census data using CPS to obtain current-year denominators for fatality rates [Cohen et al., 2006]. Nevertheless, the small CPS sample size in Oregon (1,130 households) is clearly inadequate for making accurate estimates of stratified worker populations in the state. The number of all loggers in the state, for example, according to CPS in both May and November 2004, was zero. CPS is not used for any denominators in the results presented here.

BLS Local Area Unemployment Statistics

LAUS provides county-level employment data, and unlike similar data sources, also counts farm and self-employed workers, making it the best source for current estimates of the total employed labor force. LAUS state employment figures are constituted from CPS, the BLS Current Employment Statistics Survey, and state unemployment insurance systems, and applies a number of weighting, referencing, and imputing procedures to combine and correct the totals [Bowler and Morisi, 2006]. Due to the partial coverage of the BLS employment survey and the state insurance systems upon which it is based, and the high level of unreliability of CPS data, substate

estimates for counties and metropolitan areas require additional correction measures, including use of the Census and annual population estimates. LAUS does not provide data for stratified worker populations by industry, occupation, or demographic characteristics.

BLS Occupational Employment Statistics

BLS provides detailed data on the number of workers in a large number of occupations, based on a semi-annual Occupational Employment Statistics (OES) Survey; but does not count self-employed workers. The survey is conducted by the states and administered to firms covered by state unemployment insurance. The sampling frame includes all firms in a 3-year rotating cycle. Data are produced by a kind of moving average that takes into account past survey results. Sampling and nonsampling error may produce unreliable estimates for the numbers of workers in some occupations. The sampling error is published with the estimated count in each occupation listing; nonsampling error remains unknown.

Oregon Labor Market Information System (OLMIS)

State employment data, available online, only accounts for workers covered by Workers' Compensation. Reports and archived data refer principally to industry categories, but OLMIS also publishes employment projections by occupation for the state and 15 workforce regions, with a more extensive list than is available through BLS. Differences between OLMIS and BLS figures can be pronounced, with the OLMIS number in a particular occupation sometimes near the edge or beyond the BLS error estimate. Despite differences, the raw employment data for both systems is the same, collected by the states according to BLS methodology, then sent to BLS for modeling before publication in the national occupational employment data archive. Like BLS, OLMIS occupation estimates are modeled using national surveys, other national data sources, and state unemployment insurance system data. Topical reports by state analysts provide valuable perspective on data and trends.

Applications

Oregon FACE surveillance data for traumatic occupational fatalities was compared to incidents recorded by other surveillance systems to assess differences. Numbers of incidents (numerators) were compared to death certificates, Workers' Compensation, and CFOI. Denominator data obtained from the U.S. Census, LAUS, and BLS Occupational Employment Statistics were used to produce fatality rates for represented populations.

Oregon Vital Records provides quarterly reports to Oregon FACE for death certificates marked for an injury "at work." Additional death certificates are obtained for individual cases not identified in the quarterly reports. For this study, Vital Records was queried back to 2003 to ensure a complete list of death certificates marked "at work" for the period 2003–2007. FACE case files were reviewed for the same period to record the number of "at work" death certificates.

This is the only portion of the study that used confidential files. The Oregon FACE project is approved to conduct research by the Institutional Review Board at Oregon Health & Science University and observes confidentiality regarding the names of persons and firms. All other data sources used in the results below were available online. CFOI data were obtained from published reports and double-checked by the Oregon CFOI analyst.

For the FACE-CFOI comparison, a statistical test was applied to measure interrater reliability, using an intraclass correlation coefficient (ICC) in a two-way random-effects analysis of variance [Shrout, 1998; Koepsell and Weiss, 2003; Savic et al., 2007]. For the analysis of fatality rates by age, using denominators from the Census and the American Community Survey, odds ratios were computed with p-values, using a convenient online tool for 2×2 contingency tables provided by Vassar College (VasserStats: http://faculty.vassar.edu/lowry/odds2x2.html).

The calculation of fatality rates by occupation, focusing on logging, used BLS data rather than OLMIS, in consideration of the ready availability of BLS archived data for cross-state comparisons, and the published error estimates. Sometimes, however, BLS data are absent for loggers. Missing data in the 2003 and 2005 BLS files were imputed from the nearest available years to compute an average employment number over the period 2003–2007. In addition, the number was multiplied to include 30% self-employed in the total. An OLMIS report on fallers estimated 28% of all fallers were self-employed [Stevenson, 2005]; in the Census 2000, 31.6% of all employed males in Agriculture/Forestry/Fishing were self-employed.

RESULTS

The sections below present Oregon FACE data, 2003–2007, first in comparison to other numerator sources for occupational fatalities; and then in fatality rates calculated for Oregon workers using denominators from different data sources for age, county, and occupation. The average occupational fatality rate in Oregon, 2003–2007, was 4.0 per 100,000 workers per year (numerator from Oregon FACE, denominator from LAUS), the same as the national average over the same period.

TABLE I. Oregon FACE Incidents and Death Certificates "at Work," 2003–2007

	Count	Percentage differences
Oregon FACE	352	
DC "At Work"	350	99% of FACE
FACE/DC Match	276	78% of FACE
DC Overcount	74	21% of DC not FACE
DC Undercount	76	22% of FACE missed by DC

Numerator: Death Certificates

A comparison of Oregon FACE incidents to death certificates marked ''at work'' over a 5-year period, 2003–2007, shows a crude, nearly complete association in the total numbers (Table I). Yet only 78% of the cases directly match. The overcount by death certificates involve cases outside the FACE inclusion criteria, including incidents that (i) occurred out of state, (ii) involved a heart attack or other nontraumatic medical condition, or (iii) were not at work. For those cases missed by death certificates, but counted by FACE, notable omissions included motor vehicles (29%), air transportation (20%), farm/ranch/fishing workers (21%), and violence (13%). In addition, a number of missed cases (9%) involved delayed death, where the original event was remote. In a few missed cases (4%), a clear incident at work was not marked. A few other missed cases (4%) involved heart attacks, included by FACE as events with a work-related traumatic injury as the primary factor.

Numerator: Workers' Compensation

Of the 352 occupational fatalities recorded by Oregon FACE, 2003–2007, only 161 (46%) were registered by the state Workers' Compensation system. Total WC cases during the period was 198, with a segment not counted by FACE: 30 involving Oregon workers out of state, five involving long-term asbestos or other exposure, and two involving a commute (probably counted as WC cases because both incidents occurred in a company vehicle).

The high percentage of worker fatalities missed by Workers' Compensation (Table II) greatly expands the typical notion of ''self-employed'' as defined by other methods [Mirabelli et al., 2003; Bunn et al., 2006; Mulloy et al., 2007]. The category spans a wide range of industries. Notable here is the complete absence in the WC data of incidents involving fishermen and artists, as well as a majority of truck drivers. A substantial proportion of workers are missed in agriculture, construction, logging, and even in manufacturing. Regarding personal characteristics (data not shown), WC coverage did not disproportionately underrepresent workers by race/ethnicity or most age categories, except for workers under age 16 (missed 2 of 2; 100%), and workers aged 65 and over (missed 34 of 44; 77%).

TABLE II. Oregon FACE Incidents Missing in Workers' Compensation Data by Industry and Event, 2003–2007

Industry	Missing count	Missing percentage
Accommodation/Food Services	3	100
Arts/Entertainment/Rec	12	100
Fishing	16	100
Transportation	49	84
Education Services	6	67
Agriculture	21	62
Other Services	3	60
Public Administration	7	54
Information	1	50
Profession/Science/Tech	2	50
Construction	22	49
Retail Trade	5	42
Manufacturing	14	36
Admin/Support/Waste/Remed.	10	36
Forestry/Logging	15	33
Health Care/Social Asst	1	33
Real Estate/Rental/Leasing	1	33
Wholesale Trade	2	20
Mining	1	17
Missing Total	191	54
Events	**Missing count**	**Missing percentage**
Transportation (water)	23	100
Violence	22	88
Transportation (air)	20	80
Exposure	11	52
Fire/Explosion	4	50
Overexertion	2	50
Falls	22	49
Transportation (motor vehicle)	49	48
Contact	33	43
Transportation (mobile machinery)	5	24
Missing total	191	54

Numerator: Census of Fatal Occupational Injuries

As far as we can find, this is the first published comparison of CFOI and FACE data by industry, occupation, and event. The comparison of coding by the two independent surveillance systems shows noticeable areas of ''noise'' in the cells (Tables IIIa–IIIc). The total number of incidents recognized by Oregon FACE, 2003–2007, was 352; the total number by Oregon CFOI was 356.

TABLE IIIa. Oregon FACE and CFOI Incidents by Industry, 2003–2007

Industry	FACE	CFOI
Industry totals	352	331
11 Agriculture/Forestry/Fishing/Hunting	**94**	**93**
Agriculture	34	
Forestry/Logging	44	34
Fishing	16	16
21 Mining/Extraction	**6**	**3**
Utilities, Trade, Transportation (22,42–49)	**86**	**91**
22 Utilities	4	
23 Construction	**45**	**53**
31–33 Manufacturing	**39**	**43**
42 Wholesale Trade	10	14
44–45 Retail Trade	12	3
48–49 Transportation/Warehousing	60	64
Financial activities	**6**	**3**
51 Information	2	
52 Finance/Insurance	1	
53 Real Estate/Rental/Leasing	3	
Professional and Business Services	**31**	**13**
54 Professional/Scientific/Tech Services	4	
55 Management of Companies, Enterprises	0	
56 Admin/Support/Waste/Remediation	27	3
Educational and Health Services	**12**	**13**
61 Educational Services	9	5
62 Health Care/Social Assistance	3	3
Leisure and Hospitality	**15**	**3**
71 Arts/Entertainment/Recreation	12	
72 Accommodation/Food Services	3	
81 Other Services	**5**	**7**
92 Public Administration	**13**	**9**

Categories in bold are the sum of subcategories in plain text. CFOI categories do not always sum correctly, due to data suppression.

TABLE IIIb. Oregon FACE and CFOI Incidents by Event, 2003–2007

Event	FACE	CFOI
Event totals	352	346
0 Contact	**77**	**73**
1 Falls	**45**	**45**
2 Overexertion	**4**	
3 Exposure	**21**	**17**
4 Transportation	**172**	**184**
Transportation (motor vehicle)	103	
Transportation (mobile machinery)	21	
Transportation (air)	25	15
Transportation (water)	23	
5 Fires/Explosions	**8**	**3**
6 Violence	**25**	**24**

TABLE IIIc. Oregon FACE and CFOI Incidents by Occupation, 2003–2007

Occupation	FACE	CFOI
Occupation totals	352	344
Management and Professional (11–29)	**34**	**45**
Management, Business, Finance (11–13)	16	28
11 Management	16	28
13 Business/Finance	0	
Professional (15–29)	18	15
15 Computer/Math	1	
17 Architecture/Engineering	2	
19 Life, Physical, Social Sciences	1	
21 Community, Social Services	0	
23 Legal	1	
25 Education/Training/Library	5	
27 Arts/Design/Entertain./Sports/Media	6	
29 Healthcare Practice, Technical	2	
Service (31–39)	**34**	**30**
31 Healthcare Support	0	
33 Protective Service	12	10
35 Food Preparation, Serving Related	2	
37 Building, Grounds Maintenance	15	
39 Personal Care, Service	5	
Sales and Office (41–43)	**15**	**14**
41 Sales and Related	10	4
43 Office/Administrative Support	5	3
45 Farming/Fishing/Forestry	**72**	**70**
Farm/Ranch	28	12
Fishing	16	18
Forestry	4	2
Logging	24	32
47 Construction/Extraction	**50**	**50**
Construction	45	
Mining	5	
49 Install/Maintenance/Repair	**27**	**24**
51 Production	**25**	**22**
53 Transportation/Material Moving	**89**	**89**
Transportation	80	
Material Moving	9	
55 Military	**6**	

The total incidents for CFOI categories do not always sum to correct totals, due to data suppression to protect confidentiality. It is not readily apparent what differences are due to CFOI's missing published data, or due to coding differences.

The many differences in the data produce only a small effect on the overall reliability between the two coding systems. Comparing all unique data points over 5 years shows substantial agreement, according to intraclass correlation coefficients. For all unique codes, the ICC statistic

was .962 (CI = 0.947–0.973, $P < .001$). The correlation held up well for subcategories by industry, occupation, event, and year. Occupation showed the lowest correlation: ICC = 0.903 (CI = 0.842–0.942, $P < 0.001$). Coding for occupation is evidently more susceptible to interpretation than coding for industry or event.

Denominator: U.S. Census

State data from the U.S. Census 2000 was used to obtain the distribution of the employed labor force by age. Computing occupational fatality rates and odds ratios by age category show older workers at higher risk. With 5 years of data, small annual counts in Oregon FACE data accumulated enough power to reach statistical significance where pronounced differences existed.

Extrapolating Census data forward according to growth in the state's total employed labor force (according to LAUS), will not change the age distribution or the odds ratios, and errors may occur as the Census date becomes more distant. Therefore, age data were also examined from the annual American Community Survey (ACS). The results show the average annual ACS data, 2003–2007, appear too skewed from the Census results to be accurate (Table IVa). Modifications in ACS methods in 2005, and the first 3-year estimate, 2005–2007, produced more credible data; yet, compared to the projected Census totals, two areas in all of the ACS age categories appear suspect: the sharply diminished total for the youngest workers, and the sharply increased number for workers aged 55–64. Using LAUS totals for the state's total employed population as the most reliable baseline, even the Census 2000 appears to be subject to undercounting. The Census is known to miss peak employment during the summer months [Richardson et al., 2004; Morrissette, 2010].

Without making a choice among the available denominators, odds ratios were calculated for the Census and three versions of ACS data to compare the effects of the different age distributions (Table IVb). Prime-age adult workers, aged 25–44, were selected as the comparison group.

Higher risk for younger workers appears slightly elevated, but the difference does not reach statistical significance. In contrast, all older worker categories are more

TABLE IVa. Oregon Employed Labor Force by Age in Different Datasets, 2003–2007

Age Category	Census 2000	Projected Census 2003–2007 (Avg/yr)	ACS 2003–2007 (Avg/yr)	ACS 2005–2007 (Avg/yr)	ACS 2005–2007 (3-year est.)
0–15	0	0	0	0	0
16–19	79,971	82,455	61,532	71,484	71,255
20–24	160,982	165,983	132,696	166,489	162,486
25–44	772,174	796,163	626,179	792,061	788,450
45–54	399,391	411,799	336,690	426,657	427,161
55–64	168,843	174,088	195,522	255,882	256,608
65+	46,408	47,850	47,216	58,405	58,399
Totals	1,627,769	1,678,339	1,399,835	1,770,978	1,764,359
LAUS Totals	1,716,954	1,752,483	1,752,483	1,782,763	1,782,763

Census for 2003–2007 average per year projected from LAUS growth rate.

TABLE IVb. Oregon Occupational Fatality 5-Year Odds Ratios by Age, Compared to Prime-Age Workers, Using Different Employed Labor Force Denominators

Age category	FACE incidents 2003–2007	Census 2000	ACS 2003–2007 Avg/yr	ACS 2005–2007 Avg/yr	ACS 2005–2007 3-year est.
0–15	2	–	–	–	–
16–19	15	1.23	1.29	1.41	1.41
20–24	30	1.22	1.20	1.21	1.23
25–44	118	1.00	1.00	1.00	1.00
45–54	93	1.52*	1.47*	1.46*	1.45*
55–64	50	1.94**	1.36**	1.31**	1.30**
65+	44	6.21**	4.95**	5.06**	5.04**
Total	352				

Statistically significant differences: *$P < .01$; **$P < .001$.

likely to be involved in a fatal incident compared to prime-age adult workers, and all of the differences show a strong statistical significance. Risk increases sharply for workers aged 65 and over. Only the Census denominator exhibits the expected positive relationship of increasing risk with age [Rogers and Wiatrowski, 2005].

Denominator: Local Area Unemployment Statistics

LAUS data for total employment provide a reliable denominator to produce fatality rates for the 36 Oregon counties. Counties with low populations and few incidents, however, produce highly unstable rates. Selecting only those counties with more than five incidents during the 5-year period, a ranking system was adopted from a Washington state study to target priority areas of concern [Silverstein et al., 2002; Bonauto et al., 2006]. The procedure involves ranking categories by the associated fatality count, and then by fatality rate, and averaging the two ranks to produce a single index. Although the procedure glosses over differences in magnitude between the original ranked categories (as noted by the authors), it appears to provide a reasonable way to direct attention to priority areas with high rates, without neglecting areas of high incidence.

The Washington state index ranking was applied to industry categories; here the index is applied to counties (Table V). This choice is made possible by LAUS data, and is used to emphasize the opacity of such a diffuse category as ''industry'' or ''county,'' which both fail to define a risk exposure. The Washington state authors in the latest article on prioritizing industries for injury prevention [Bonauto et al., 2006] discuss a few interesting ways to investigate risk factors more closely and target interventions using available Workers' Compensation data.

In the top results here, Oregon FACE case narratives provide further insights:

- Malheur County, a frontier county with a sparse rural population, is prominent due to a single motor-vehicle incident with eight fatalities. Remaining incidents relate to various ranch activities, two with airplanes, and three with workers aged 70 and over.
- Tillamook County is prominent due to a major cluster of incidents with crab fisherman crossing the bar from the port at Garibaldi; Oregon FACE responded in 2010 with a research initiative to investigate what safety measures might be effective and acceptable to fishermen.
- Klamath County presents an inordinate number of farm and transportation incidents related to heavy trucks on an off the highway, and violence, with no clear target audience.
- Curry County is prominent, again, due to a number of incidents related to crab fishing, plus other fishing and water-transportation incidents.

TABLE V. Oregon Counties Rank Index by Occupational Fatality Count and Rate, 2003–2007

Avg rank	County	Employed labor force	Fatality count	Fatality rate per 100,000/yr	Count rank	Rate rank
1	MALHEUR	11,805	16	27.11	6	1
2	TILLAMOOK	11,544	14	24.25	8	2
3	KLAMATH	27,767	19	13.69	5	9
4	CURRY	8,817	10	22.68	12	3
5	DOUGLAS	43,332	15	6.92	7	12
6	COOS	26,199	12	9.16	10	10
6	BAKER	6,702	6	17.91	16	4
7	LANE	164,654	24	2.92	2	19
7	LINCOLN	20,546	10	9.73	12	9
7	CLATSOP	17,986	9	10.01	13	8
7	WASCO	12,051	8	13.28	14	7
8	MULTNOMAH	346,072	42	2.43	1	22
8	DESCHUTES	70,740	15	4.24	7	16
8	JOSEPHINE	31,793	11	6.92	11	12
9	CLACKAMAS	181,176	23	2.54	3	21
9	LINN	48,493	13	5.36	9	15
9	JEFFERSON	8,510	6	14.10	16	8
10	UMATILLA	34,092	10	5.87	12	13

Employed labor force from LAUS 2003–2007 average per year.

Denominator: BLS Occupational Employment Statistics

Oregon FACE surveillance quickly identified logging as a priority area of concern, with multiple fatalities each year among a small population of workers. The clearest occupations at risk were tree fallers and log truck drivers. Over time, it became clear that several other occupations involved in yarding operations were also at risk, especially chokersetters and other rigging workers, plus landing workers—all ground personnel—in a variety of events. According to BLS occupational statistics, Oregon currently employs more loggers than any other state, and the highest proportion of workers on the ground.

BLS and OLMIS occupation categories for direct logging operations include tree fallers, equipment operators, and ''all others'' (interpreted here as ground personnel). OLMIS breaks out log truck drivers under transportation and heavy trucks, but the category is unavailable through BLS. According to cross-industry allocation reported by OLMIS, nearly all fallers and ground personnel work in the logging industry; the few workers in other industries may be presumed to be performing similar logging activities. The work of fallers is distinct, and the denominator presents a pointed risk exposure. The work of ground personnel can include various occupations, including mechanics and supervisors, as well as a majority involved in yarding logs in the brush and at the landing, carrying out a variety of tasks. The numerator and denominator for ground personnel represent a more diffuse category than that for fallers (Table VI). If members of the rigging crew could be distinguished in the denominator as a specific risk environment, the fatality rate would probably be greater than the results shown.

The standard error in the BLS employment estimate for fallers is among the highest in the occupations database, with a mean 36% confidence interval from the base during the period covered. Consequently, the estimated fatality rate for fallers of 241 per 100,000 workers per year could be as high as 378, or as low as 176. The error factor for the number of ground personnel is much smaller, resulting in a more stable fatality rate: close to 83 per 100,000 workers per year.

DISCUSSION

This assessment of available state-level data sources for the composition of occupational fatality rates indicates levels of reliability. Examples provide direction for producing reasonably accurate and meaningful rates in specific contexts.

Numerators

FACE and CFOI surveillance systems, with the same inclusion criteria, provide the most complete data for state-level occupational fatalities. Results in the comparison of Oregon FACE data to death certificates confirm a level of error observed in an earlier comparison with state FACE data in Kentucky [Bunn et al., 2006], which found death certificates marked ''at work'' captured only 76% of the total cases identified by FACE surveillance (78% in the results here). The study did not mention the separate error factor of death certificates also overcounting the number of cases at work.

The most thorough comparison of ''at work'' death certificates to CFOI data by Biddle and Marsh [2002], showed a general match of 84% nationwide, and a match in Oregon and a few other states of 93–100%. These high rates of correspondence are difficult to reconcile with the present results. However, the pattern of incidents missed by death certificates in that study reflected the same pattern detected here, including transportation incidents, outdoor workers, and violence.

Results in the comparison to Workers' Compensation data emphasize its limited scope, and areas where the

TABLE VI. Fatality Rates for High-Risk Logging Occupations, 2003–2007

	Covered employment	Total labor force (30% self-employed)	Fatality rate per 100,000/yr
Fallers			
FACE Incidents 2003–2007		12	
Avg Total Labor (BLS base)	698	997	241
Avg Total Labor (BLS low est.)	444	634	378
Avg Total Labor (BLS high est.)	952	1,360	176
Ground Personnel			
FACE Incidents 2003–2007		11	
Avg Total Labor (BLS base)	1,850	2,643	83
Avg Total Labor (BLS low est.)	1,625	2,321	95
Avg Total Labor (BLS high est.)	2,075	2,964	74

majority and sometimes all incidents are missed. This is partly due to WC exclusion criteria, omitting out-of-state workers injured in Oregon, certain workers in public administration, and suicide—all included by FACE. One study [Oleinick and Zaidman, 2004] concluded a ''very high'' proportion of the employed workforce is covered by Workers' Compensation, but the results here make that conclusion doubtful. Even in surveyed industries—where Workers' Compensation systems commonly claim to count 98% of the labor force—the results here indicate significant numbers of workers are missed. Serious undercounting of the total number of injuries in the WC system resulted in a Congressional report on the issue [U.S. House of Representatives, 2008].

Even CFOI data must be used with caution, partly due to data suppression that removes cases, so that few of the numbers make auditable totals. Regional researchers face the problem of data suppression in the Census and other government data sources for small areas, and have developed elaborate procedures in efforts to reconstitute the missing data [Isserman and Westervelt, 2006]. The comparison of FACE and CFOI data also shows notable differences in coding, though the two surveillance systems work with parallel inclusion criteria. Identifying the precise reasons for differences would require closer scrutiny of individual cases, which is currently not possible, due to federal confidentiality restrictions.

Denominators

The assessment of denominators for occupational fatality rates shows that even Census data has weaknesses, and cannot always be assumed to be the correct alternative. The Census and ACS data proved useful to definitely distinguish an area of concern for older workers, especially aged 65 and over. A closer look at the incidents involving these workers (through narratives available online in Oregon FACE annual reports) shows a correlation to work in and around heavy vehicles: large trucks, tractors, bulldozers, and so on, both on and off the highway.

No effort was made to translate the numbers for workers in the presented age categories into hours-based employment, according to the current BLS standard. Further attention to hours-based denominators at the state level could modify the results by amplifying the level of risk associated with younger and older workers, who are more likely to work fewer hours [Ruser, 1998].

Acquiring denominators for stratified populations at the state level is limited. Denominators for industry categories covered by state unemployment insurance are the easiest to obtain, though they omit a number of self-employed workers, which must be factored in to produce a comprehensive view. The results here demonstrated fatality rates by county may be produced for all workers, using LAUS data.

For both industry and county, the abstract categories are diffuse and require further interpretation to produce meaningful targets for intervention. This consideration explains why imprecision in the index of priority areas (combining the rankings of incidence and rate) is not a major concern. An actionable priority requires additional criteria: a clearly identified risk factor, a target population, and opportunities to reach the audience and reduce the hazard in a cost-effective manner. Ranks alone are not decisive.

Occupation categories come closer to actual worker risk exposure, appropriate for a denominator, but obtaining an accurate number for a specific category of workers is difficult, particularly for high-risk outdoor occupations with seasonal variation and high proportions of self-employed workers, such as agriculture, fishing, logging, and construction.

In relation to the fatality rates presented in the results for high-risk logging occupations, the rates could be affected by errors in the addition of self-employed workers to represent 30% of the total employed labor force. The independent nature of the work for fallers encourages self-employed contract cutters, meaning the proportion self-employed could be higher, which would increase the denominator and reduce the fatality rate. The opposite is true for ground personnel. The organized nature of yarding operations makes registered employment more likely, and the estimate of 30% self-employed may be too high. If so, the population of workers would be smaller, and the fatality rate higher.

Considering the difficulties in characterizing risk in any available population data, state researchers should consider multiple data sources and options to obtain representative denominators for specific categories of workers. In regard to occupation, the results here demonstrated how BLS employment statistics could be used for denominators, but there is apparently little confidence in this data source by state analysts. Fatality rates by occupation are rarely reported at the state level, and when reported, tend to use denominators from the Current Population Survey. Without a single reliable data source, Lincoln and Lucas [2010] from the NIOSH Alaska field station computed fatality rates for commercial fishermen in U.S. local fisheries using a combination of sources: the number of participating vessels (licenses), the number of days at sea (catch data), and the average number of crew members onboard each vessel (vessel size). Clearly, a better, single data source is needed to allow results to be replicated by different state analysts, following the same methods and assumptions. Present budget constraints for national data systems make this a doubtful prospect [Benson, 2009].

Ultimately, though, rates are only a rough guide, not a scientific fact, useful for directing attention in progressive steps toward field investigation. Too much precision is probably unnecessary. As an example, the very high fatality rate for Oregon commercial crab fishermen is masked when subsumed under the industry category of Farming/Fishing/Forestry, and only gains marked attention when drawn out as a specific occupation. Incidents may then be associated through analysis of expanded event codes to problems with capsized vessels and weather, or more closely through case files with crossing a bar and not wearing a personal flotation device; but only upon inspecting a major cluster of incidents on location at an Oregon port does local knowledge indicate a primary problem with the eroded south jetty, which no longer coordinates with the extended arm of the north jetty to properly flush the channel, so the bar has become increasingly treacherous. Other examples of research to practice in public health illustrate the need to translate data into specific instances and direct field work [e.g., Lincoln et al., 2008]. The origin of applied epidemiology in the 1850s still provides an ideal standard, when John Snow was led by data on cholera deaths to investigate water supplies door to door in particular London neighborhoods [Monson, 1990]. Rates confirm and locate areas of concern to propel action.

CONCLUSION

This study presented Oregon FACE data on occupational fatalities, 2003–2007, compared FACE data to other fatality surveillance systems, and explored the process of composing occupational fatality rates with denominators from available data sources. The assessment of data sources and identification of several priority areas of concern in Oregon may help state researchers direct their own efforts to target priorities for effective interventions.

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