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How Much Work-Related Injury and Illness is Missed By the Current National Surveillance System?

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Learning Objectives

- Summarize data collected by the U.S. Bureau of Labor Statistics (BLS) on the prevalence of work-related illnesses and injuries in the state of Michigan, and on risk rates for different forms of employment.
- Appraise the ability of BLS estimates to accurately determine the frequency of illnesses and injuries, separately and together, compared to that of four other Michigan data bases combined.
- Outline possible problems with the current BLS system for estimating work-related illnesses and injuries, and what measures might be adopted to obtain more precise estimates for help in deciding how to allocate available public health resources.

Abstract

Objective: We sought to estimate the undercount in the existing national surveillance system of occupational injuries and illnesses. **Methods:** Adhering to the strict confidentiality rules of the U.S. Bureau of Labor Statistics, we matched the companies and individuals who reported work-related injuries and illnesses to the Bureau in 1999, 2000, and 2001 in Michigan with companies and individuals reported in four other Michigan data bases, workers' compensation, OSHA Annual Survey, OSHA Integrated Management Information System, and the Occupational Disease Report. We performed capture–recapture analysis to estimate the number of cases missed by the combined systems. **Results:** We calculated that the current national surveillance system did not include 61% and with capture–recapture analysis up to 68% of the work-related injuries and illnesses that occurred annually in Michigan. This was true for injuries alone, 60% and 67%, and illnesses alone 66% and 69%, respectively. **Conclusions:** The current national system for work-related injuries and illnesses markedly underestimates the magnitude of these conditions. A more comprehensive system, such as the one developed for traumatic workplace fatalities, that is not solely dependent on employer based data sources is needed to better guide decision-making and evaluation of public health programs to reduce work-related conditions. (J Occup Environ Med. 2006;48:357–365)

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The national surveillance system for occupational injuries and illnesses, which is administered by the U.S. Department of Labor Bureau of Labor Statistics (BLS), is based on reports from employers. As stated on the BLS web site: “The responsibility for collecting statistics on occupational injuries and illnesses was delegated to the Bureau of Labor Statistics. In order to further the purposes of this act (OSHA), the language was quite specific: ‘the Secretary of Labor shall compile accurate statistics on work injuries and illnesses which shall include all disabling, serious or significant injuries and illnesses, whether or not involving loss of time from work other than minor injuries requiring only first aid treatment and which do not involve medical treatment, loss of consciousness, restriction of work or motion, or transfer to another job.’”

The national statistics on occupational injuries and illnesses are derived from a sampling strategy rather than a census of all work-related injuries and illnesses. In response to a National Academy of Sciences report in 1987,¹ which showed that the BLS national estimates missed 50% of acute work-related deaths, BLS began the Census of Fatal Occupational Injuries (CFOI). CFOI is a complete census that uses multiple data sources, covers all workers, and is not dependent on an employer either being aware of the condition or responding to a survey. However, no such system has ever been implemented to improve the national

estimates for nonfatal work-related injuries and illnesses.

A number of studies have documented that the current system to derive national estimates for work-related injuries and illnesses undercount both chronic conditions and acute injuries.²⁻¹³ These studies were based on comparisons of counts of work-related injuries or illnesses from nonemployer-based data sources, such as hospital discharge data, or medical records with the BLS estimates but were not based on an actual matching of individuals reported within the different systems. We present the results of matching both the number of reports of injuries and illnesses, and individuals with days away from work and companies from multiple databases, from companies who participated in the BLS annual survey in Michigan in 1999, 2000, and 2001.

We present the numbers and percentage of work-related injuries and illnesses missed in Michigan by the BLS survey estimates. We use capture-recapture analysis to estimate the number of injuries and illnesses missed in Michigan by both BLS and Workers' Compensation. We present these data for overall injuries and illnesses and also by specific conditions and industrial sectors.

Materials and Methods

Data Sources

A summary of the five data bases used in the analysis for the years 1999, 2000 and 2001 follows:

BLS Annual Survey. The BLS survey is an annual survey of a sample of employers by state, industry type, and employment size (www.bls.gov/iif/home.htm). In all states, it excludes the self-employed, farms with fewer than 11 employees, private households, and federal employers. In 27 states, but not Michigan, public employees are excluded. All injuries and illnesses from facilities in the mining and railroad sectors tracked by the U.S. Department of Labor Mine Safety and Health Administra-

tion and the Department of Transportation's Federal Railroad Administration are included in the BLS survey results. Using appropriate sampling weights and a nonresponse adjustment factor, total estimates of injuries and illnesses and estimates by state and industrial sector are calculated based on the injuries and illnesses reported by the selected companies. The information collected for each company includes counts of total injuries, injuries with restricted workdays, total illnesses, illnesses with restricted workdays, and illnesses categorized by seven disease categories.

If the employer has 30 or fewer employees with injuries or illnesses with at least 1 day away from work, details about the conditions are obtained for each of the employees. If the employer has greater than 30 employees with injury or illness with at least 1 day away from work, a random time period is selected in which no more than 30 employees had an injury or illness with at least 1 day away from work. The information collected includes: employee name, date of injury or illness, number of lost workdays, but not employee social security number. BLS does *not* collect employee-level data on any cases without lost work time.

Occupational Safety and Health Administration (OSHA) Annual Survey. The OSHA annual survey is a survey of a sample of employers with one or more employees in all sectors except government, mining, railroad, postal services, private households or services (www.michigan.gov/cis/0,1607,7-154-11407_30929-39,936-,00.html). OSHA uses the survey for enforcement purposes. For agriculture, an establishment must have 11 or more employees to be included. The database does not collect details on individuals. It does include company names, total injuries, injuries with restricted days, injuries with days away from work, total illnesses, illnesses with restricted workdays, and illnesses with days away from

work and illnesses by seven disease categories.

Michigan Bureau of Workers' Disability and Compensation First Injury and Illness Reports (WC). Public and private Michigan employers are required to have Workers' Compensation insurance except the federal government, the railroads, shipping and harbor employers, employers with less than 3 employees, some agricultural employers, and the self employed (www.michigan.gov/wca).

All Michigan employers who are required to provide Workers' Compensation insurance are required to report to the Bureau of Workers' Disability and Compensation on what is titled a "Form 100" all injuries and illnesses "which arise out of and in the course of the employment, or on which a claim is made and result in any of the following: 1) disability extending beyond seven consecutive days, 2) death; or 3) specific losses." Although employers are not required to report disability lasting fewer than 7 consecutive days, approximately 20% of the reports submitted to Workers' Compensation do not meet the 7-day criteria. All Form 100 reports, including the ones that do not meet the 7-day criteria, have the individual's name and social security number, company name, number of lost workdays, date of injury, nature of injury, and body part affected. If an employer disputes the work-relatedness of the claim, then either the employee can request mediation or hearing (Form 104) or an employer can file a notice of dispute (Form 107). All Forms 100, 104, and 107 with injury dates in 1999, 2000, and 2001 were used after removing all duplicate reports. Although Forms 104 and 107 do not have the number of lost workdays, the Workers' Compensation Bureau estimated that 75% of these forms were filed for lost workday cases of at least 7 consecutive days.

Michigan Occupational Disease Reports (OD). Michigan law requires all health care providers, including hos-

pitals, clinics, laboratories, and employers, to report all known or suspected work-related illnesses but *not* injuries to the State (part 56 of PA of 1978; www.chm.msu.edu/oem/resources/mi_publiclthcode_part56.pdf). The computerized OD records contain the affected employee's name and social security number; the employer's name and address; date of diagnosis; and diagnosis or clinical impression coded according to the International Classification of Diseases (ICD-9th Revision). No information on lost workdays is collected.

OSHA Integrated Management Information System (IMIS). When a Federal or State Plan OSHA inspection is conducted in Michigan, the compliance officer reviews the injury and illness log maintained by the employer (only required if an employer has 11 or more employees). Information on the total number of injuries and illnesses (by seven disease categories) is collected. Company names are collected but not employees' names.

Data for all five aforementioned databases are collected by one agency in Michigan, the Michigan Department of Labor and Economic Growth (MDLEG). Access to the BLS annual survey data was given under the auspices of the Intergovernmental Personnel Act Assignment agreements. All access to BLS data occurred in a locked room in the BLS offices with strict review by BLS of all analyses, both electronic and paper, before the results of analyses were removed from the office.

Matching was performed at two levels: person to person matching for the three data bases that have names of individuals (BLS, WC, and OD) and company level matching for all five data bases (BLS, OSHA, WC, OD, IMIS) for the years 1999, 2000 and 2001.

Person-level matching was conducted using an algorithm model.¹⁴ Databases were compared two at a time, using the database with the fewer number of records to check against the database with the larger number of records.

The ranking system used to characterize the likelihood of potential matches was based on information about the employee's first and last name, social security number, and age at diagnosis; the nature of the injury or illness reported; the date when the injury or illness occurred; and company name and the Employer Identification Number (EIN; the EIN is a unique number assigned to companies but not individual facilities by the United States Internal Revenue Service) where the injury or illness occurred. Manual comparison of the records was performed after the initial computer matching because many records had some missing information and this also allowed us to address typographical errors, transposed numbers, and the order of words.

Acute diagnoses were matched if they were within 6 months of a previous injury and chronic diagnoses if they were within a year. There were three different schemes of diagnosis coding used (ICD 9, BLS Nature of Injury Code, and Workers' Compensation Nature of Injury Code). Because of difficulties in matching the diagnoses in the different data bases, diagnosis information was used only when the person/company information was unclear about whether the record matched.

To estimate the total number of injuries and illnesses with days away from work from the person level matches, we only used the BLS and WC databases because we were unable to identify which of the OD reports had days away from work. We performed the match for cases with greater than seven days away from work because we were concerned that the WC database was incomplete for individuals with 1 to 7 days away from work. For the relatively small number of companies (≈ 200) with more than 30 workers who had injuries or illnesses with days away from work, that BLS does subsampling, the date of injury in the worker compensation database

had to occur within the BLS subsampling date to be considered a match.

Company-level matching was conducted in a manner similar to the person-level matching except all five databases could be used. Companies that had been matched between databases from the person-level matching were considered as matching at the company-level match. After these matches were identified, the company databases were compared two at a time, using the database with the fewer number of records to check against the database with the larger number of records.

The highest level of matching was when the company name, location, and EIN matched exactly. Using the same method as the person-level match confirmation, a manual comparison of each potential set of matches was completed for the company-level matching.

To estimate the total number of injuries and illnesses derived from the company matches, we assumed that if matching companies were in more than one of the data bases that the cases reported from those companies in different databases represented the same individuals. This assumption would favor conservative results because it is likely that some of the cases recorded actually represented different people.

To derive the injury and illness estimates, we applied the BLS sampling weights adjusted for nonrespondents to the largest number recorded in any of the data bases where the company matched to a BLS company that was included in the annual survey.

To derive our final estimates we applied the percentage of undercount calculated in the person-to-person match after the capture-recapture analysis to the published BLS estimate of all Michigan injuries and illnesses.

We estimated the undercount of worker illnesses and injuries by applying standard capture-recapture methodology.^{15,16} For the BLS and WC databases, person to person matching was done in each time

period, by strata defined by injury type and facility. With independent reporting to each registry, the mean count λ_k in the k -th stratum was estimated under the assumption that the total count N_k was Poisson distributed (with mean λ_k), and that conditionally on N_k , the count of injuries in the BLS and count of injuries in the WC are binomially distributed. Finally, the stratum weights w_k were applied to get an estimate of the total count $\sum_k w_k \lambda_k$ across all strata.

Results

Table 1 shows the average number and range of companies, reports before weighting, and the final estimates for all injuries and illnesses and those with days away from work for the 3 years 1999 to 2001 for the BLS annual survey in Michigan. Table 2 shows the average WC data for the 3 years, 1999 to 2001. Table 3 shows the average number and range of reports received and companies for OD, OSHA, and IMIS for the 3 years, 1999 to 2001. Table 4 shows the company level match with weighting across the five databases. Adding all the cases provided an estimated average of 386,402 injuries and illnesses for 1999 to 2001. The BLS estimate for 1999 to 2001 on the average was 74% of the total injuries and illnesses. BLS and WC combined missed less than 1% of the total injuries and illnesses from the companies in the BLS Annual Survey.

The results for company level match within industry categories for 1999 to 2001 are shown in Table 5 and by whether it was an injury or illness in Table 6. The BLS estimates by industry ranged from 45% of total injuries and illnesses for the transportation, communications and electrical services (SIC 40–49) to 94% of total injuries and illnesses for agriculture (SIC 01–09). The BLS estimates for injuries was appreciably greater, 90% of total injuries, than that for illnesses, 50% of total illnesses.

TABLE 1

Summary of Data From the Bureau of Labor Statistics, Michigan 1999 to 2001

	1999–2001 Average (Range)
Companies	5,801 (5,555–5,934)
Injuries and illnesses before weighting	98,946 (84,538–109,365)
Number of companies reporting injury or illness	2,560 (2,412–2,719)
Injuries and illnesses with days away from work before weighting	10,161 (8,567–11,407)
Number of companies reporting injury or illness with days away from work	1,860 (1,730–2,016)
Total weighted injuries and illnesses	281,566 (258,000–296,700)
Weighted injuries and illness with days away from work	65,200 (58,300–68,400)

TABLE 2

Summary of Data From Workers' Compensation, Michigan 1999 to 2001

	1999–2001 Average (Range)
Companies claims of first reports or requests for medication or notices of dispute	25,708 (24,468–27,016)
Number of claims of first reports	58,331 (51,028–62,897)
Number of claims of first reports >7 days	49,613 (43,178–54,201)
Number of requests for medication or notices of disputes	22,335 (21,451–23,312)
Number of medical only claims	133,901 (108,567–161,882)
Total first claims and medical-only claims	192,256 (169,636–224,836)

TABLE 3

Summary of Data From Occupational Disease (OD) Reports, OSHA Survey, and Integrated Management Information System (IMIS), Michigan 1999 to 2001

	1999–2001 Average (Range)
OD	
Number of companies	687 (618–742)
Number of reports	19,579 (17,287–21,351)
OSHA	
Number of companies	3,453 (3,323–3,673)
Number of reports	106,503 (98,783–116,296)
IMIS	
Number of companies	6,269 (4,691–7,611)
Number of reports	44,644 (30,357–54,764)

Table 7 shows the person level match and capture–recapture analysis for BLS and WC. Adding all cases with greater than 7 days away from work after weighting provided an estimate of 79,379 and after including capture–recapture 95,033. This compared to the BLS data alone, which estimated 30,800 (38.8% and 32.4%). For injuries, adding all injuries there were an estimated 66,020 and 80,399 after including the capture–recapture estimate. This compared with the BLS

data alone, which estimated 26,292 injuries, 39.8% and 32.7% respectively. For illnesses, adding all illnesses there were an estimated 13,359 illnesses and 14,634 illnesses after including the capture–recapture estimate. This compared to the BLS data alone, which estimated 4508 illnesses, 33.7% and 30.8%, respectively.

These same results for person match by specific industries are shown in Table 8, by specific types of injuries in Table 9, and by specific

TABLE 4

Number of Reports of Injuries and Illness After Company Match Between the Bureau of Labor Statistics (BLS) Annual Survey, Workers' Compensation, Occupational Disease, OSHA Annual Survey, and IMIS Data Base, Michigan 1999 to 2001

Data Bases					Number of Reports, 1999–2001 Average (Range) Weighted
BLS	WC	OD	OSHA	IMIS	
Yes	No	No	No	No	55,359 (50,583–59,301)
Yes	Yes	No	No	No	127,018 (103,995–139,944)
Yes	Yes	Yes	No	No	12,349 (7,056–19,664)
Yes	Yes	Yes	Yes	No	25,693 (14,914–35,047)
Yes	Yes	Yes	Yes	Yes	25,996 (20,859–32,053)
Yes	Yes	Yes	No	Yes	3,038 (784–7,278)
Yes	Yes	No	Yes	No	38,590 (29,315–46,582)
Yes	Yes	No	Yes	Yes	27,818 (13,664–39,326)
Yes	Yes	No	No	Yes	14,835 (8,006–20,674)
Yes	No	No	No	Yes	3,075 (2,288–4,593)
Yes	No	No	Yes	No	7,603 (5,323–11,182)
Yes	No	Yes	Yes	No	1,395 (380–2,825)
Yes	No	Yes	No	No	414 (169–555)
Yes	No	Yes	No	Yes	210 (107–313)*
Yes	No	No	Yes	Yes	2,410 (1,071–4,515)
Yes	No	Yes	Yes	Yes	2,113 (1,040–3,185)*
No	Yes	Yes	Yes	Yes	—
No	Yes	No	Yes	Yes	128 (115–141)
No	Yes	No	No	Yes	2,483 (203–5,248)
No	Yes	No	No	No	35,310 (14,082–49,630)
No	Yes	No	Yes	No	991 (167–2,011)
No	Yes	Yes	No	No	—
No	Yes	Yes	Yes	No	25 (–)
No	Yes	Yes	No	Yes	—
No	No	Yes	Yes	Yes	—
No	No	No	Yes	Yes	169 (–)
No	No	No	No	Yes	—
No	No	Yes	No	No	—
No	No	Yes	Yes	No	—
No	No	Yes	No	Yes	—
No	No	No	Yes	No	—
Total					386,402 (352,138–442,047)†

*There was no number for a year as the number was suppressed to comply with BLS confidentiality rules.

†Total includes individual rows of matching database combinations that were suppressed because of small numbers to comply with BLS confidentiality rules.

OD, occupational disease; IMIS, Integrated Management Information System; WC, worker's compensation; OSHA, Occupational Safety and Health Association.

types of illnesses in Table 10. Our estimate of all injuries and illnesses in Michigan averaged 869,034 for the 3 years (Table 11).

Discussion

On the basis of the results of our analysis, we estimate that the number of work-related injuries and illnesses in Michigan is three times greater than the official estimate derived from the BLS annual survey. We

estimate there were an average of 869,034 injuries and illnesses per year in Michigan from 1999 to 2001, not 281,567 per year as estimated by BLS. To derive these total estimates, we used capture–recapture analysis of our estimate of the BLS undercount from Table VII for greater than 7 days away from work. The analysis in Table 7 is based on the actual matching of persons with injuries and illness reported by companies in

the BLS survey (Table 11). This analysis indicated that the BLS survey only captured 31% to 33.5% of the total estimate of annual injuries and illness. Although the BLS undercount, which ranged from 512,149 to 645,484 work-related injuries and illnesses per year appears very large, this estimate is consistent with a recent analysis based on statistical models that BLS missed 33% to 69% of work-related injuries alone without considering how many additional work-related illnesses were being missed.⁶ The BLS estimate of work-related injuries and illness is equivalent to 1 in 15 workers a year in Michigan with a work-related injury or illness whereas our estimate is one in five; although the estimated incidence would be less as some workers may have more than one injury/illness per year. Even our estimate may undercount the true burden because, the self employed and most agriculture are not included in the BLS and WC databases and both of these systems are likely to miss illnesses with long latency periods such as the pneumoconiosis and cancer.

The data we used for these analyses demonstrate that alternate databases report additional cases beyond what a company reports to BLS either when they report some cases or when a company reports they have no cases. In the top half of Table 4, where a company in BLS reported at least one case, additional cases were identified from the other databases. The bottom half of Table 4 shows cases identified in companies in the BLS survey where those companies said they had no cases but alternate data bases indicated there actually were cases. Workers' Compensation was the largest source of cases missed by the BLS survey.

There are multiple reasons why the current BLS national system for estimating work-related injuries and illnesses is incomplete: 1) lack of coverage of government workers in half the states although not in Michigan where government workers are

TABLE 5

Number of Reports of Injuries and Illnesses After Company Match Between BLS Annual Survey, Workers' Compensation, Occupational Disease Reports, OSHA, and IMIS by Industry, Michigan 1999 to 2001

Standard Industrial Classification	BLS 1999–2001 Average (Range)	Percent*
Agriculture, forestry, fishing (01–09)	3,233 (2,900–3,700)	94 (87–99)
Mining (10–14)	533 (500–600)	77 (74–81)
Construction (15–17)	15,733 (14,400–16,900)	79 (73–86)
Manufacturing (20–39)	125,100 (109,600)	83 (77–92)
Auto Manufacturing (37)	(47,833) (43,400–51,600)	77 (63–90)
Transportation, comm., elec. svcs (40–49)	14,733 (12,000–16,200)	45 (26–58)
Wholesale trade (50–51)	15,433 (12,800–19,300)	65 (49–82)
Retail trade (52–59)	35,167 (31,600–37,500)	61 (54–70)
Finance, insurance, real estate (60–67)	3,133 (3,100–3,200)	67 (46–92)
Services (70–89)	39,800 (38,500–42,400)	52 (48–61)
Public Administration (91–97)	9,367 (9,100–9,700)	69 (66–75)

*Percent of total combined BLS, WC, OD, OSHA, and IMIS estimates reported by BLS. For abbreviations, see Table 4 footnote.

TABLE 6

Company Match Between BLS Annual Survey, Workers' Compensation, Occupational Disease, OSHA, and IMIS by All Injuries and All Illnesses, Michigan 1999 to 2001

Injury/Illness	BLS 1999–2001 Average (Range)	Percent*
All illnesses	35,500 (31,700–37,400)	50 (32–80)
All injuries	246,133 (226,300–259,300)	90 (89–90)

*Percent of total combined BLS, WC, OD, OSHA and IMIS estimates reported by BLS. For abbreviations, see Table 4 footnote.

TABLE 7

Person Match Between Bureau of Labor Statistics (BLS) Annual Survey and Workers' Compensation (WC) Claims, Michigan 1999 to 2001

BLS	WC	Number of Individuals 1999–2001 With >7 Days Away From Work Average (Range)
Combined		
Yes	Yes	13,685 (9,025–17,594)
Yes	No	17,115 (14,462–18,791)
No	Yes	48,579 (45,614–54,079)
No	No	15,654 (8,236–19,691)
Total		95,033 (80,967–106,996)
Standard error		(3,622)
Injuries		
Yes	Yes	11,850 (8,231–15,683)
Yes	No	14,442 (12,089–15,704)
No	Yes	39,728 (36,746–44,189)
No	No	14,379 (7,669–17,748)
Total		80,399 (68,350–89,105)
Standard error		(3,589)
Illnesses		
Yes	Yes	1,835 (794–2,799)
Yes	No	2,673 (2,373–3,259)
No	Yes	8,851 (7,796–9,890)
No	No	1,275 (567–1,943)
Total		14,634 (12,617–17,891)
Standard error		(487)

covered; 2) lack of coverage of the self-employed and farms with fewer than 11 employees in all states; 3) the perception by employers of financial and regulatory disincentives for complete reporting; 4) employers not knowing about former employees or retirees who develop diseases with a long latency period between first exposure and manifestation of the disease (eg, pneumoconiosis); 5) socioeconomic disincentives for employees of making their employer aware of a work-related condition; and 6) the use of a sampling strategy, rather than a complete census.

Even if one expanded the BLS annual survey to include Workers' Compensation information our data indicate a substantial percentage of cases would still be missed (~18%; Table 7). These estimates of missed cases do not include injuries not covered by either the BLS annual survey, or Workers' Compensation such as the self-employed, family farmers, and Federal employees. It is estimated that exclusion of these workers causes an additional 25% undercount beyond that missed by undercounting of BLS and WC covered employers.⁶

There are a number of assumptions and limitations associated with our analyses. To identify people, we had the Social Security Number for all data sets except BLS (90% missing), which made it necessary to do textual matches on people's names. BLS often did not have the full first name or there was a variation in the first (eg, Robert versus Bob) or last name (eg, marriage or spacing). Last name and first name alone was not enough to match a person (eg, John Smith). And additional fields such as age, date of birth and employer information were used. When matching companies we were missing the EIN for OSHA and OD. Even when an EIN is available it is assigned to the corporate entity not the specific facility. This made it necessary to do textual matches on company names and addresses. To minimize overestimating the BLS undercount, ques-

TABLE 8

Person Match Between Bureau of Labor Statistics (BLS) Annual Survey, and Workers' Compensation (WC) Claims for >7 Days Away from Work by Industry, Michigan 1999 to 2001

Standard Industrial Classification	BLS 1999–2001 Average (Range)	Percent*	Percent†
Agriculture, forestry, fishing 01–09	342 (326–399)	62 (54–72)	58 (50–65)
Mining 10–14	129 (103–168)	100 (–)	49 (46–51)
Construction 15–17	3,641 (3,320–3,851)	63 (60–67)	57 (56–60)
Manufacturing 20–39	10,243 (8,219–11,266)	48 (44–53)	38 (33–40)
Auto Manufacturing 37	(3,006) (2,287–3,876)	47 (40–57)	35 (26–43)
Transportation, comm., elec. svcs 40–49	2,605 (2,392–3,015)	14 (9–20)	10 (8–12)
Wholesale trade 50–51	1,694 (1,398–2,114)	63 (55–75)	59 (48–71)
Retail trade 52–59	3,455 (2,783–4,050)	37 (29–50)	36 (27–49)
Finance, insurance, real estate 60–67	477 (390–594)	62 (51–69)	58 (49–63)
Services 70–89	5,921 (5,502–6,401)	46 (36–56)	40 (31–51)
Public Administration 91–97	2,292 (2,148–2,548)	59 (50–68)	51 (41–61)
Total	30,800 (27,117–33,226)	39 (37–41)	33 (31–34)

*Percent of total combined BLS and WC estimates reported by BLS.

†Percent of total including capture-recapture estimates reported by BLS.

‡Published BLS numbers differ from calculated total because of rounding.

TABLE 9

Person Match Between Bureau of Labor Statistics (BLS) Annual Survey, and Workers' Compensation Claims (WC) for >7 Days Away from Work by Injury, Michigan 1999 to 2001

Injury	BLS 1999–2001 Average (Range)	Percent*	Percent†
00, 09	3,131 (2,617–3,910)	46 (39–51)	46 (39–51)
00. Traumatic injuries, unsp.	(1,491) (1,087–1,998)	94 (92–96)	94 (92–96)
09. Other traumatic injuries	(1,640) (1,229–1,913)	32 (23–40)	32 (23–40)
01, 02	17,416 (14,912–18,798)	37 (34–40)	31 (30–33)
01. Traumatic injuries to bones	(4,192) (3,531–4,598)	53 (50–55)	52 (49–54)
02. Traumatic injuries to muscles, tendons, etc	(13,222) (11,380–14,198)	34 (30–38)	29 (28–30)
03, 04, 05	4,091 (3,896–4,314)	58 (56–61)	56 (55–58)
03. Open wounds	(1,945) (1,681–2,104)	47 (42–50)	46 (42–49)
04. Surface wounds and bruises	(1,743) (1,557–1,910)	81 (73–86)	81 (73–85)
05. Burns	402 (287–471)	52 (47–55)	52 (47–55)
06. Intracranial injuries	109 (73–141)	54 (40–81)	54 (40–81)
07. Effects of environmental conditions	—	—	—
08. Multiple traumatic injuries	1,066 (896–1,179)	39 (34–41)	38 (33–41)

*Percent of total combined BLS, and WC estimates reported by BLS.

†Percent of total including capture-recapture estimates reported by BLS.

Totals were not calculated because of differences in nomenclature of Injury/Illness recording schemes in BLS and in WC.

TABLE 10

Person Match Between Bureau of Labor Statistics (BLS) Annual Survey, and Workers' Compensation (WC) Claims for >7 Days Away from Work by Illness, Michigan 1999 to 2001

Illness	BLS 1999–2001 Average (Range)	Percent*	Percent†
7a. Skin	71 (50–107)	38 (33–48)	38 (33–48)
7c. Respiratory conditions due to toxic agents	26 (2–50)	23 (3–40)	23 (3–40)
7d. Poisoning	35 (0–84)	51 (0–100)	51 (0–100)
7e. Disorders due to physical agents	21 (0–45)	29 (0–54)	29 (0–54)
7f. Disorders associated with repeated trauma	1,957 (1,821–2,212)	59 (54–65)	57 (53–64)
7g. Other	16,447 (14,244–17,421)	34 (30–37)	28 (27–30)

*Percent of total combined BLS and WC estimates reported by BLS.

†Percent of total including capture-recapture estimates reported by BLS.

Totals were not calculated because of differences in nomenclature of Injury/Illness recording schemes in BLS and in WC.

TABLE 11

Illustration of Calculations Used to Estimate Total Number of Injuries and Illnesses based on Individual with Greater Than 7 Days Away from Work, Michigan 1999 to 2001

BLS	WC	1999–2001 Average (Range)	
Yes	Yes	13,685 (9,025–17,594)	A
Yes	No	17,115 (14,462–18,791)	B
No	Yes	48,579 (45,614–54,079)	C
No	No	15,654 (8,236–19,691)	D
Total		95,033 (80,967–106,996)	Total/(A + B + C + D)
Cases in BLS and/or WC		79,379 (72,731–87,305)	A + B + C
Cases in BLS only		30,800 (27,117–33,226)	A + B
Percentage captured by BLS without capture-negative estimate		0.388 (0.373–0.410)	(A + B)/(A + B + C)
Percentage captured by BLS where total includes capture-recapture estimate		0.324 (0.310–0.335)	E = (A + B)/(A + B + C + D)
BLS Estimate		281,567 (258,000–296,700)	F
Our Estimate		869,034 (770,149–935,484)	F/E

tionable matches were considered matches.

BLS only collects personal identifiers on individuals with days away from work. When matching the total number of injuries and illnesses, we assumed that reports of injuries and illnesses from the same companies in different databases represented the same people. This clearly was not true. Where we had information on the individual, we found that cases in the different databases from the same companies were definitely not identical. Partly due to this conservative assumption, we found much less of an undercount by BLS for all injuries and illnesses (10%; Table 4) than for those with days away from work (61%; Table 7). Intuitively, it does not make sense that there is more under recording for the severe cases that have days away from work as compared to all cases. However, a survey of employer records from 200 establishments in 1987 in Massachusetts and Missouri and a nationwide survey of employer records from 250 establishments in 1998 showed that under recording of lost workday injuries was two to three times as frequent as under recording for all cases 25% versus 10% in 1987 and 22% to 33% versus 11% in 1998.¹⁷

The larger difference in undercount for days away from work cases

may be partly explained by the differences in recording by companies. We have anecdotal knowledge that in some larger companies that the individual responsible for completing the BLS annual survey and maintaining the OSHA log from which the BLS annual survey is derived is different from the person in the company responsible for tracking workers' compensation. Any discrepancy in recording cases in the BLS and worker compensation databases would be greater for cases with days away from work which were potentially included in the worker compensation database in contrast to the medical only claims which were not. However, it is likely that a large part of the difference is secondary to the fact that we overmatched for all injuries and illnesses where no information on individual people was available. Finding matches between the databases when one does not truly exist will increase the BLS estimate and accordingly decrease any estimated undercount.

Capture-recapture depends on a number of assumptions, including 1) all cases in the population have the same probability of being identified in the different data bases and 2) ascertainment in the different data bases is independent between any two data sources.¹⁸ The likelihood that an employer became aware of a workplace injury and

illness will vary by company. As described previously, who completed the BLS annual survey and their awareness of who has filed for Workers' Compensation may differ by company. One would also suspect that Workers' Compensation and the BLS annual survey are not independent, ie, being in one likely increase the chance of being in the other database. If this were true then the capture-recapture estimate would favor the BLS annual survey appearing more complete than it really is and would not account for the BLS undercount reported in this analysis. Furthermore, if one ignored the estimated cases missed according to the capture-recapture analysis, the BLS estimate still missed 61% of cases as compared to 68% when capture-recapture results were included (Table 7).

The number of cases missed varied by industry category 0% to 86% (Table 8). Our results show that there was more variation in incomplete reporting between types of injuries (6–71%; Table 9) and types of illnesses (43–77%; Table 10) than between all injuries combined and all illnesses combined (67% versus 69%) across all industries (Table 7). Accordingly, one cannot use a single factor to account for the underestimate. For certain industries like agriculture there did not seem to be much of an

undercount. One would like to think that was because the injuries and illnesses were being captured but it is more likely given the nature of farming in Michigan, self-employed and not covered by either the BLS annual survey, OSHA inspections nor the WC system that all systems were missing cases from this industry.

To obtain more accurate estimates of work-related injuries and illnesses, changes in the current system will be needed to address the undercount. The development of the national CFOI system for occupational fatal injuries is an example of basic changes that were implemented to correct the undercount in fatal work-related injuries. CFOI uses multiple data sources that cover all employees and data sources that are not dependent on an employer either being aware of the condition or submitting the report. No such comprehensive system for nonfatal work-related injuries and illnesses exists at either the national or state level. Azaroff et al¹⁹ has described the conceptual filters that lead to underreporting: worker needs to report injury/illness or medical care to supervisor; health care provider needs to recognize work-relatedness; treatment needs to be charged to workers' compensation; health care provider needs to participate in an occupational disease-reporting system; and the injury/illness needs to be recorded by the employer. Any comprehensive system that is designed in the future will need to address potential impediments at each of these decision points to ensure more complete reporting than the current system.

A more comprehensive surveillance system for work-related injuries and illnesses would be useful to inform decision-making on the allo-

cation of public health resources to occupational health and safety in comparison to other public health issues and to prioritize, target and evaluate both public health and enforcement activity to reduce work-related injuries and illnesses.

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References

1. National Research Council. *Counting Injuries and Illnesses in the Workplace: Proposals for a Better System*. Washington, DC: National Academy Press; 1987.
2. Boyle D, Parker D, Larson C, Pessoa-Brand AOL. Nature, incidence and cause of work-related amputations in Minnesota. *Am J Ind Med*. 2000;35:542–550.
3. Islam SS, Edla SR, Mujuru P, Doyle EJ, Ducatman AM. Risk factors for physical assault state-managed workers' compensation experience. *Am J Prev Med*. 2003;25:31–37.
4. Landrigan PH, Baker DB. The recognition and control of occupational disease. *J Am Med Assoc*. 1991;266:676–680.
5. Leigh JP, Markowitz SB, Fahs M, Shin C, Landrigan PJ. Occupational injury and illnesses in the united states. estimates of costs, morbidity and mortality. *Arch Intern Med*. 1997;157:1557–1568.
6. Leigh JP, Marcin JP, Miller TR. An estimate of the US Government's undercount of non fatal occupational injuries. *J Occup Environ Med*. 2004;46:10–18.
7. Nelson NA, Park RM, Silverstein MA, Mirer FE. Cumulative trauma disorders of hand and wrist in the auto industry. *Am J Public Health*. 1992;82:1550–1552.
8. Park RM, Nelson NA, Silverstein MA. Use of medical insurance claims for the surveillance of occupational disease: an analysis of cumulative trauma in the auto industry. *J Occup Med*. 1992;34:731–737.
9. Pransky G, Snyder T, Dembe A, Himmelstein J. Under-reporting of work-related disorders in the workplace: a case study and review of the literature. *Ergonomics* 1999;42:171–182.
10. Roscoe RJ, Ball W, Curran JJ, et al. Adult blood lead epidemiology and surveillance—United States, 1998–2001. *MMWR*. 2002;51:1–10.
11. Rosenman KD, Reilly MJ, Henneberger PK. Estimating the total number of newly-recognized silicosis cases in the United States. *Am J Ind Med*. 2003;44:141–147.
12. Stanbury M, Reilly MJ, Rosenman KD. Work-Related Amputations in Michigan, 1997. *Am J Ind Med*. 2003;44:359–367.
13. Windau J, Rosenman KD, Anderson H, et al. The identification of occupational lung disease from hospital discharge data. *J Occup Med*. 1991;33:1061–1066.
14. Biddle J, Roberts K, Rosenman KD, Welch EM. What percentage of workers with work-related illnesses receive workers' compensation? *J Occup Environ Med*. 1998;40:325–331.
15. International Working Group for Disease Monitoring and Forecasting. Capture-recapture and multiple-record systems estimation I: history and theoretical development. II: applications in human diseases. *Am J Epidemiol* 1995;142:1047–1058 and 1059–1068.
16. Selvin S. *Practical Biostatistical Methods*. Belmont, CA: Duxbury Press; 1995.
17. Conway H, Svenson J. Occupational injury and illness rates, 1992–96: why they fell. *Monthly Labor Rev*. 1998;121:36–58.
18. Hook EB, Regal RR. Capture–recapture methods in epidemiology: methods and limitations. *Epidemiol Rev*. 1995;17:243–264.
19. Azaroff LS, Levenstein C, Wegman DH. Occupational injury and illness surveillance: conceptual filters explain underreporting. *Am J Pub Health*. 2002;92:1421–1429.