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Work-Related Amputations in Michigan, 1997

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Background *Work-related amputations are of concern in Michigan and nationally. This study reports on 1 year of data on work-related amputations, which were treated in Michigan hospital emergency departments (ED) or as in-patients in Michigan.*

Methods *Michigan hospitals provided face sheets and discharge summaries of in-patient and ED visits for work-related amputations that occurred in 1997. Information was also obtained about worksite inspections associated with reported amputations from the Michigan Occupational Safety and Health Act (MIOSHA) program. Data from this study and from Michigan workers compensation were used to generate an estimate of the true numbers of work-related amputations in Michigan in 1997.*

Results *Three hundred thirty-nine work-related amputations were identified by hospitals. Powered saws and power presses were the leading sources of injury. MIOSHA completed 30 enforcement inspections related to these amputations. Our best estimate of the total numbers of work-related amputations in 1997 for Michigan was 693, of which 562 resulted in hospitalization or ED treatment.*

Conclusions *In-patient and ED records provided information for identifying high risk groups and problem worksites in Michigan. Estimates generated from these data underscore that data on work-related amputations released by the Bureau of Labor Statistics (BLS), which reported 440 amputations in 1997, are a significant undercount—only 64%—of the true number of cases. Better integration of public health data into OSHA enforcement activity is needed.* Am. J. Ind. Med. 44:359–367, 2003. © *2003 Wiley-Liss, Inc.*

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INTRODUCTION

Amputations are among the most serious and debilitating injuries that can occur at work. The consequences for workers who suffer losses though amputation are lifelong; these individuals must learn to work with lost digits or limbs, affecting their viability in the workforce as well as having an impact on their personal lives. Machines and powered hand tools are the most common sources of amputation injuries. The Bureau of Labor Statistics (BLS) estimated that in 1997, 10,852 amputations resulting in days away from work occurred in the private sector in the United States, for an incidence rate of 11 per 100,000 employed individuals. Out of concern for the adverse effects of amputations, the Federal Occupational Safety and Health Administration (OSHA) has established a national emphasis program to reduce amputations [OSHA, 2001, 2002], and the Michigan OSHA

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program's current 5 years Strategic Plan includes specific goals for the reduction of amputations.

Several state-based occupational injury surveillance programs have piloted surveillance systems for work-related amputations using various methods for data collection and case follow-up [Sorock et al., 1993; Boyle et al., 2000]. This study describes public health surveillance data for work-related amputations in Michigan, using in-patient and emergency department (ED) reports of work-related amputations, and provides some case studies of work-site investigations by the Michigan Occupational Safety and Health Act (MIOSHA) enforcement program.

METHODS

In 1998, all 161 hospitals in Michigan with medical and surgical beds were sent a letter requesting that they provide face sheets, discharge summaries, and/or ED records of patients age 16 and older who were given medical care for a work-related amputation in 1997. Follow-up to determine completeness of reporting for inpatient hospitalizations was conducted by comparing the hospitals' response to the mailing with the complete data set of hospital discharges maintained by the state hospital association. Hospitals were re-contacted about amputation discharges that did not match with reports and they were asked either to confirm that the case was not work-related or to provide the discharge summary so that the researchers could make that determination. It was not possible to confirm completeness of reporting of ED patients because no agency collects a complete data set of ED visits in Michigan. This study was approved by the Michigan State University Human Subjects Review Board.

Information abstracted from the records provided by hospitals included: birth date; gender; race and ethnicity; anatomical site(s) affected; whether the amputation was partial or complete; equipment or other object, substance or exposure that produced the injury (injury source); a brief narrative of the injury event; employer name and what the company produced; date of hospital encounter; primary insurance coverage; and whether the patient was hospitalized or seen in the ED or other non-hospitalized setting without hospitalization. If the record indicated both an ED encounter and hospitalization, the case was counted as in-patient. Workers' compensation was presumed to be the primary insurance if ''workers' compensation'' was written on the face sheet, the name of the employer was written on the face sheet under ''responsible party,'' or workers' compensation was coded as the primary payer in the hospital discharge computer record. Date of hospital encounter was considered the date of injury. The equipment or other source that produced the injury was coded using the Bureau of Labor Statistics Occupational Injury and Illness Classification system [Toscano et al., 1996; BLS, 2002a]. The type of industry where the amputation occurred was coded according to the US Department of Labor's Standard Industrial Classification (SIC) System [Office of Management and Budget, 1987]. Data for the number of employed persons used to calculate injury rates by industry were provided by the Geographic Profile of Employment and Unemployment compiled by the federal BLS for agriculture, forestry, and fishing [BLS, 1999]. For all other industries, the 1997 annual average employment for Michigan was provided by the Labor Market Analysis Section, Michigan Department of Career Development.

During the data collection process in 1998, names of selected employers were submitted to the MIOSHA program to give MIOSHA the opportunity to conduct an investigation of the incident. MIOSHA provided the study with copies of paper files of completed inspections. In 2002, names of all employers were matched with OSHA's computer file of completed inspections (their Integrated Management Information System or ''IMIS'') that is available on the OSHA website [OSHA, 2003]. An enforcement inspection involving the amputation was presumed to have occurred when there was a match on employer name and address and a safety inspection had been completed within 6 months following the injury. Results of MIOSHA activities were abstracted into the data set.

An estimate of the true number of work-related amputations that resulted in ED or in-patient treatment in Michigan was developed based on the following assumptions: first, we believe the number of in-patient reports received from the hospitals was accurate, based on follow-up using the state-wide hospital discharge computerized data set. Second, we assume that hospitals reporting only in-patients did not search their ED records for work-related amputation cases. We developed the estimate of the total number of ED treated amputations by using an estimate of the ratio of in-patient to ED cases in our data. This was done as follows: the number of in-patient cases was summed for those hospitals that reported ED cases. The ratio of in-patient to ED cases calculated from these hospitals was multiplied by the total number of in-patient cases in the study from hospitals that did not report ED data. This estimated number of ED treated amputations was added to the actual number of ED amputations reported to obtain our estimate of the total number of ED treated amputations, which was then added to the actual in-patient total to obtain our estimate of the total number of work-related amputations treated in hospitals or EDs.

An estimate of the total number of work-related amputations in Michigan was obtained by calculating the percentage of amputations in this study where the primary payer was not workers compensation. This percentage was divided into the total number of worker compensation claims filed for amputations in the same year to estimate the total number of work-related amputations.

RESULTS

Surveillance Findings

Three hundred thirty nine work-related amputations were reported by 85 (53%) of 161 Michigan hospitals with medical and surgical beds. Follow-up with the hospital discharge data set and individual hospital record room staff confirmed that the other 76 hospitals had not had any patients hospitalized for work-related amputations. One hundred ten (32%) individuals were hospitalized overnight, 222 (65%) were seen in the ED only, five (2%) were seen in a hospital outpatient clinic, and for two (1%) the type of hospital site could not be determined. Of the 83 hospitals that reported in-patients or ED patients (two hospitals reported only outpatient clinic patients), 22 reported in-patients only, 39 reported ED patients only, and 22 reported patients in both categories. Follow-up using the hospital discharge data set found 27 additional amputation cases where there was insufficient record to determine if the amputation was or was not work-related. Of these 27 cases, for one the payer was workers' compensation and we estimated that another 12 were work-related because approximately 45% of all hospitalized amputations in Michigan are work-related. None of these 27 cases were included in our study because the hospitals could not find these patients' records.

Males comprised the great majority (290 or 86%) of cases. Data on race was missing on 22% of the reports. Two hundred seventeen (82%) of the 265 individuals with known race were classified as white, 39 (15%) were African American, and nine (3%) were of other races. Hispanic status was missing on more than 81% of the reports. The age distribution of the individuals is illustrated in Table I. Three of the amputations were among workers under the age of 18. Two of the three working minors were injured in food establishments, including a 17 years old who lost an arm in a meat grinder and a 17 years old who had two fingers partially amputated in a food processor. The third, age 17, had several fingers crushed between concrete at a construction job.

TABLE I. Work-Related Amputations: Age at Time of Injury—Michigan, 1997

Age group	Number	Percent (%)
Less than 25	52	16
Less than 18	(3)	(1)
25–34	96	28
35–44	83	25
45–54	66	19
55–64	28	8
65+	14	4
Total	339	100

Anatomical site

Amputations ranged in severity from a single partial finger amputation to loss of entire extremities. Individuals with single finger amputations were the most common (71%). Loss of major body parts (hands, feet, legs) involved 14 (4%) of the injured individuals (Table II).

Month of injury

The number of amputations peaked in October, the second most frequent month was March. There were no patterns of injury source, anatomic site, or type of industry that were associated either with the 2 peak months or the month of June, which had the fewest number of amputations.

Source of injury

Power presses were the leading source of injury, involving 37 (12%) of the 298 work-related amputations where source was known. A greater proportion of the power-press-related amputations involved multiple fingers than all the other work-related amputations (30% compared to 21%). One of the two work-related foot amputations was the result of a power press that fell and crushed the worker's foot. Two of the five individuals with work-related hand amputations and one of the six with an arm amputation involved power presses. Thirty-three (89%) of the 37 incidents were covered by workers' compensation, two were covered by commercial insurance, and payer source for the remaining two was unknown (Table III).

Other leading sources of work-related injury included powered saws, both stationary (24 or 8%) and portable

TABLE II. Frequencies of Amputations by Anatomic Site—Michigan, 1997

Anatomical site	Number	Percent (%)
Fingers	316	93
Single finger	(242)	(71)
Multiple fingers	(74)	(22)
Toes	8	2
Single toe	(3)	
Multiple toes	(5)	
Hands/feet	7	2
One hand	(3)	
One hand and fingers of other hand	(1)	
Two hands	(1)	
One foot	(2)	
Extremities	7	2
One arm	(6)	
One leg	(1)	
Unknown	1	<1
Total	339	100

TABLE III. Source of Injury, Where Source Was Identified—Michigan, 1997 (N = 298)

Source	Number	Percent (%)
Machines	188	63
Power presses	(37)	
Stationary powered saws	(24)	
Food-related (e.g., slicers, mixers, meat grinders)	(20)	
Conveyers	(11)	
Boring, drilling	(10)	
Lawnmowers	(6)	
Parts and materials	26	9
Chains, pulleys, rollers	(9)	
Animals	2	1
Structures and surfaces	8	3
Doors	(4)	
Tools, instruments, and equipment	48	16
Portable powered saws	(19)	
Vehicles	20	7
Cars	(2)	
Forklifts	(8)	
Explosives	1	<1
Containers	3	1
Furniture/fixtures	2	1
Total	298	100

(19 or 6%) and food processing machines such as slicers and grinders (20 or 7%). Forklifts were responsible for one of the two foot amputations and the one work-related leg amputation. Injuries were so severe in the latter case that the individual ultimately expired. The one individual with both hands amputated was working on a cardboard cutting machine.

Industry and workers' compensation

The majority (59%) of the amputations occurred in manufacturing. Twenty-seven (8%) of the work-related amputations occurred in agriculture, and included two of the six work-related arm amputations. Thirty-one of the 32 amputations in the transportation equipment category were specifically in motor vehicle parts and accessories manufacturing. Twenty-six (8%) of the amputations occurred in wholesale and retail food establishments, including 13 in retail food stores. The highest incidence rate among broad industry categories was in agriculture (29/100,000) and the second highest was in manufacturing (20.8/100,000). Within manufacturing, the highest rates was in lumber and wood products (100/100,000), where 11 (65%) of the 17 amputations were due to powered saws and the reminder to a woodsplitter (1), an auger (1), and other/unspecified machinery (4) (Table IV).

Workers' compensation was identified as the payment source in 276 (89.3%) of the 309 cases where payment source was known. The percent of injuries covered by workers' compensation was considerably less in agriculture (47.6%) and construction (76.2%) than in the other industry groups. Workers' compensation payer status was unknown for the three amputations among minors. Among the 11 individuals age 65 and older for whom payment source was known, workers compensation was the payer in 72.7%.

Results of MIOSHA Inspections

MIOSHA provided paper copies of their records of enforcement inspections at 17 companies and the IMIS data search identified another 13 companies where a MIOSHA inspection was presumed to have covered amputation incidents identified in our study. Thus, a total of 30 or only 8.8% of the companies had an OSHA inspection performed as a consequence of an amputation. The following three case studies summarized from MIOSHA inspection records illustrate the types of amputation events investigated and MIOSHA findings.

Case study 1

A power house repairman in his forties who had worked at an automotive parts manufacturing facility for 21 years (with 16 years as a repairman) was preparing to repair a blower motor in a bag house that had inadequately guarded belts and pulleys. The motor had been turned off but the belts and pulleys to the motor were still turning when the worker began to examine the motor to determine what was wrong with it. The worker placed his gloved hand into the pulley; his hand was subsequently pulled into the motor and he suffered from an amputation of the tip of his left ring finger. The employee spent the night at a local hospital and was able to return to work 2 days later with restrictions.

The company was cited for failure to provide guards for belts and pulleys that are 7 ft or less above the floor or platform. According to the safety inspector's report, the motor had been without guards for over 1 year. Subsequently, the company installed proper guards.

Case study 2

A 19-year-old general laborer who had been working for over 1 year at a saw mill amputated his left hand when he reached under a saw to position a piece of lumber. The saw blade caught the cuff of his glove which then pulled his hand into the saw. He sustained a significant blood loss and was airlifted to a major hospital where his four fingers and thumb were successfully reattached. The patient still works at the saw mill.

TABLE IV. Industries Where Work-Related Amputations Occurred, Rates by Major Industry and Selected Two Digit SIC Code Groups, and Workers' Compensation Coverage Within Each Major Industry Group—Michigan, 1997 (N = 339)

Industry group (SIC)	Number/percentage of individuals	Rates: industry groups per 100,000 civilian employed labor force in Michigan	Number/percentage covered by workers' compensation in each group
Agriculture	27 (8%)	29	10/21 (47.6%)
Mining (oil/gas)	1 (<1%)	—	1/1 (100%)
Construction	24 (7%)	13	16/21 (76.2%)
Manufacturing	201 (59%)	20.8	176/187 (94.1%)
Food products (20)	11	26.8	9/11 (81.8%)
Lumber and wood products (24)	17	100	15/16 (93.8%)
Furniture and fixtures (25)	9	23	8/9 (88.9%)
Rubber and plastics products (30)	18	26.8	18/18 (100%)
Primary metals (33)	18	48.6	13/13 (100%)
Fabricated metals (34)	33	25.7	30/33 (90.9%)
Industrial machinery (35)	18	13.3	16/17 (94.1%)
Electronic and other electric equipment (36)	1	2.9	1/1 (100%)
Transportation equipment (37)	32	11.1	32/32 (100%)
Transportation and public utilities	7 (2%)	4	6/7 (85.7%)
Wholesale trade	5 (1%)	2.1	4/4 (100%)
Retail trade	28 (8%)	3.4	25/26 (96.2%)
Food stores (54)	13	14.7	11/12 (91.7%)
Finance, insurance, real estate	1 (<1%)	—	0
Services	21 (6%)	1.7	18/20 (90%)
Public administration	1 (<1%)	—	1/1 (100%)
Unknown industry	23 (7%)	—	19/20 (95%)

The company was cited for inadequate guarding of the saws and for one employee not wearing safety glasses at the time of the inspector's visit. Proper guards were installed and employees were reminded of the requirement to wear safety glasses at all times.

Case study 3

A press operator in his forties who had worked for 6 months at a facility that manufactures medical supplies and automotive racing parts (valves) was hand feeding a trim press when he reached his hand into the press and it activated with his hand still inside. The press punched a hole through his hand and required his right middle and ring fingers to be surgically amputated. According to employee interviews, the press would occasionally malfunction and the operators would have to manually reset the press.

The company was cited for several violations including inadequate guarding of electrical equipment, failure to perform regular safety inspections of equipment, failure to provide a feeding device for the trim presses, and failure to maintain an injury and illness log.

Estimation of the True Numbers of Work-Related Amputations

Sixty-one of the 85 reporting hospitals reported ED cases with or without inpatient cases. These included 54 in-patients and 222 ED patients. The ratio of ED to in-patient cases in this group (4.11) was applied to the 56 in-patient cases from the 24 hospitals not reporting ED cases, to estimate that those hospitals should have reported 230 ED cases. This results in an estimated 452 ED cases and, when added to the 110 in-patients, a state wide estimate of 562 work-related amputations hospitalized or treated in emergency rooms for an estimated annual incidence rate of 11.8/100,000.

There were 619 amputations reported to the Michigan workers' compensation program for 1997. This number would exclude those without workers' compensation coverage (e.g., self-employed, some farming) but would include amputations that were treated in health care settings other than hospitals. In our study, 89.3% of the work-related amputations where payment source was identified were covered by workers' compensation. Assuming that the 619 cases in the Michigan workers' compensation system were

89.3% of all work-related amputations, then we would estimate that that the true number of work-related amputations in Michigan in 1997 was 693.

DISCUSSION

This study identified 339 work-related amputations in Michigan in 1997; using these data we estimated that there were 562 amputations that resulted in ED or in-patient treatment, for an estimated annual incidence rate of 11.8/100,000, and 693 amputations overall, for an estimated incidence of 14.4/100,000. The Minnesota work-related amputation surveillance system [Boyle et al., 2000], which was based primarily, but not entirely, on workers' compensation reports rather than hospital data, calculated an amputation rate of 19.5 per 100,000. The New Jersey study, which only included hospitalized finger amputations, published an incidence rate of 9.3 per 100,000 [Sorock et al., 1993].

Risk factors for work-related amputations identified in our study are consistent with findings from studies in Minnesota [Olson et al., 1986; Boyle et al., 2000], Illinois [Oleske and Hahn, 1992], New Jersey [Sorock et al., 1993], and across 30 states [Harner, 1988]. Although these studies and ours have spanned 20 years and have used different combinations of data sources (workers' compensation, outpatient clinic, hospital in-patient or ED data), they all have identified powered saws and power presses as the leading amputation sources. They have also identified agriculture and manufacturing as the leading industries of individuals sustaining an amputation, and construction and food service as having the next highest rates.

Power presses are a particularly serious concern. Data from the BLS indicate that approximately 10% of amputations that occur each year are among power press operators [BLS, 1983]. The National Institute for Occupational Safety and Health [NIOSH, 1987] issued a Current Intelligence Bulletin in 1987 on the injury hazards of mechanical power presses, calling additional attention to this hazard, and making recommendations for safe operating practices that supplement those prescribed in OSHA standards. In 1997, federal OSHA announced a special emphasis program to reduce injuries from mechanical power presses [OSHA, 1997] and in 2002 issued Directive Number CPL 2-1.35: ''*National Emphasis Program on Amputations*,'' which targets all types of power presses, and is not limited to mechanical power presses [OSHA, 2002].

Federal OSHA, and the Michigan OSHA program by adoption, has very stringent requirements for mechanical power press construction and operation. The MIOSHA regulation also has a requirement for employer reporting of ''point of operation injuries or injuries within the confines of the die'' related to mechanical power presses.[1] Data from MIOSHA indicated that five (19%) of the 27 employers identified by name in press-related amputations were inspected by MIOSHA for the amputation. There is no way of determining how many of these power press amputations were actually reported to MIOSHA, because paper files of employer investigations are purged after 3 years and MIOSHA does not maintain any electronic data that could identify reports by employers of power press injuries. It should be noted there was insufficient information to determine completely which of the power press-related amputations met the definition of the MIOSHA requirement for reporting, except for the foot amputation, which clearly did not. This is because the type of power press (mechanical, but not hydraulic or punch press amputations are required to be reported) and the specifics of the part of the machine involved were not known.[2] The inspection conducted by MIOSHA discussed above (case study 3) illustrates the importance of the MIOSHA inspection for identifying hazards associated with press machines.

Powered saws have been a vexing safety problem both in the workplace and at home [Becker et al., 1996]. The most successful injury prevention approaches to this problem are likely to involve improved product design. Innovations such as a saw blade sensor that can detect the difference between a piece of wood and human flesh [CNN, 2002] may help to reduce these injuries.

Although only three amputations were identified among minors, these three cases are important sentinel events indicating the need for urgent follow-up. Under the federal *Fair Labor Standards Act*, certain jobs are designated as especially hazardous for employees under age 18 and these employees are prohibited from operating certain machines. The one individual whose arm was amputated by a meat grinder was operating a prohibited machine. MIOSHA conducted an investigation of this injury; the employer was cited for 14 violations (ten serious) and assessed $4,500 in penalties. A number of studies have described the special concerns for adolescents who work [Suruda and Halperin, 1991; Miller and Kaufman, 1998; Schober et al., 1998].

Likewise, older workers are vulnerable. A smaller percent of individuals age 65 and older were covered by workers' compensation (72.7% compared to 89.3% overall). Older individuals may be more vulnerable to injury because of physiologic factors and because they have taken ''post-retirement'' jobs in small, less regulated industries on a part-time basis without benefits or dedicated safety-training programs. Eight or 57% of this age group worked in manufacturing compared to 87% overall. Although injuries may be less common in older workers, they are often more

[1] Part 24. R 408.12413. Michigan Administrative Code. *Mechanical Power Presses.*

[2] The MIOSHA program has indicated that their inspection activity has not identified large numbers of unreported point of operation mechanical power press injuries during review of injury and illness logs, further suggesting that some of the power press amputations in this study were related to equipment other than what is covered by the reporting rule—Martha Yoder (personal communication).

severe in nature [Kisner and Pratt, 1997; Layne and Landen, 1997].

Overall, only 30 (12%) of the 260 work-related amputations where employer name was known appeared to have been investigated by MIOSHA, including only 16% of the 186 more severe injuries that involved more than a single-digit, partial finger amputation. Better integration of public health data with intervention activity would assist in reducing the occurrence of these preventable conditions.

Hospital discharge data are a very useful source for work-related public health surveillance [Stanbury, 2000]. Having public health authority to obtain named data has made it possible for a variety of occupational injury and illness surveillance programs to follow-back with patients, identify the worksite and at-risk co-workers, and take a combination of consultative and regulatory actions to mitigate risks [Maizlich, 2000]. Work-related amputation studies in Minnesota and New Jersey, which have included follow-back interviews, have demonstrated the specific value of amputation-related information provided by the injured worker, including information about the safety elements, such as machine guards, which were or were not in place prior to the injury or put in place subsequently. Even without follow-back information, our study has demonstrated that the source of the injury and the name of the employer, which are critical information items for targeting high risk activities and conducting interventions, can be identified from the face sheet and patient encounter record.

Hospital ED data have been used by the Consumer Product Safety Commission and researchers for injury surveillance, and their utility in public health surveillance, including occupational health, is recognized [Hunting et al., 1994; Layne and Landen, 1997; Hirshon, 2000; Jackson, 2001; National Association of Health Data Organizations (NAHDO), 2002]. Michigan has recently developed an ED injury surveillance system (Michigan Emergency Department Community Injury Information Network or MEDCIIN) that can provide a useful surveillance tool for work-related amputations and other work-related injuries.

We used MEDCIIN data to check our estimate of work-related amputations. MEDCIIN was established in 1999 to collect injury data from a sample of EDs in Michigan. The sample was designed to be representative of the state. Twenty three hospitals submitted data on all ED encounters with the diagnosis coded ICD-9 800-999 for 2000. MEDCIIN also captured the payment source for each case, including workers' compensation. It has been estimated[3] that data collected under MEDCIIN comprised approximately 18.4% of all injury cases seen in EDs in Michigan in 2000. The MEDCIIN data identified 113 amputations in 2000 with workers' compensation as the primary payer. Using the MEDCIIN estimate that this represented 18.4% of all ED work-related amputations in Michigan, it can be estimated that that there were 614 ED encounters for work-related amputations in 2000. This figure is consistent with our estimate, allowing for the fact that MEDCIIN data are from a different year than our study's data, that workers compensation most likely was not the primary payer for all work-related amputations, and concerns whether the MEDCIIN program actually receives more or less than 18.4% of all emergency room injury cases.

The estimate in our study can also be compared to the New Jersey study [Sorock et al., 1993]. Sorock cited written communication from the Consumer Product Safety Commission that 19% of amputation ED visits result in hospitalization. The 54 in-patient cases from hospitals that also reported ED cases in our study comprised 19.6% of all 276 amputations from these hospitals, a percentage nearly the same as referenced by Sorock.

Data from the BLS provide another comparison to our estimate. The BLS data are collected by an annual survey of a sample of employers, which are required by law to record and, if requested, report information on work-related illnesses and injuries among their employees. BLS data have many limitations, including the exclusion of farms with fewer than 11 employees and the self-employed and only collecting providing data on specific types of injuries, such as amputations, that resulted in days away from work. BLS estimated that there were 440 amputations in Michigan in 1997 involving days away from work [BLS, 2002], and an incidence rate of 14/100,000. It should be noted that the Minnesota study found that 90% of their amputation cases involved days away from work [Boyle et al., 2000]; this would suggest that the BLS number misses the 10% of work-related amputations that did not involve days away from work. Factoring in this 10% would increase the BLS estimate to 488 which is still less than our estimate of 562 amputations requiring hospitalization or ED treatment and our estimate of 693 for the total number of amputations. Given the limitations of the BLS data set, it is to be expected that the BLS number is lower than the estimates provided by our data. Although the BLS number is lower, the BLS incidence rate is similar because of differences in the calculation of the denominator.[4]

The other difference between our data and that of BLS are the industries with the highest amputation rates. In 1997, BLS reported that the three major industry categories nationwide with the highest amputation rates were mining, followed by manufacturing and agriculture, compared to amputations rates in our data ranking agriculture, manufacturing, and then construction in the top three. (BLS cannot

[3] Thomas Largo (personal communication); the MEDCIIN program notes that statistical methods for extrapolating from the sample to state-wide estimates are still under development.

[4] The Michigan denominator is an estimate based on a survey that counts employed persons, including part time, self-employed and agricultural workers. The BLS denominator is based on hours worked as reported by the sample of employers included in each annual survey, from which the number of full time equivalents is generated, accounting for part-time employees; it excludes the self-employed and agricultural workers.

provide state-specific amputations rates by industry.) Within manufacturing both the national rates and the rates in this study rank lumber and wood products (SIC 24) first; nationally this is followed by fabricated metal products (SIC 34) and tobacco products (SIC 21), compared to primary metals and food products being ranked second and third in this study.

There are a number of limitations in this study. We do not have data to determine the representativeness or completeness of the ED cases reported by hospitals. Although we were able to confirm that there were no inpatient amputations among the 76 non-reporting hospitals, we had no secondary data source to determine if there were ED encounters for amputations at the76 hospitals. It is likely that there were some ED cases among these 76 non-reporting hospitals, given that 39 (46%) of the 85 reporting hospitals reported ED cases only. Had we been able to determine this, it is likely that our overall estimate would have been even higher. We have no epidemiologic data on any of the amputations that were not treated in a hospital setting. We would assume that they were of lesser severity. The characteristics and risk factors among these other individuals may have been significantly different from the individuals in this study. In addition, the amount of information available in the ED and in-patient records varied and thus important information such as number of days away from work, severity of the injury, name of employer, and injury source was not always available. Finally, this study includes only 1 year of work-related amputation data; the distribution and characteristics of work-related amputations may be different in other years.

In conclusion, this study confirms the ongoing public health concerns about the risk of amputation associated with certain kinds of machinery and vulnerable groups. Estimates generated by this study and data from workers' compensation indicate that official statistics published by the BLS represent only 64% of our best estimate of the true number of work-related amputations. Undercounting of amputations in the BLS data has been evaluated as far back as 1977 [McCaffrey, 1981]. This study also indicates that hospital discharge and ED records can provide important epidemiologic information on populations and for targeting specific worksite interventions. These data sources can assist in the continued monitoring of targeted programs such as OSHA and MIOSHA's current initiatives to reduce work-related amputations. Better integration of public health data into OSHA enforcement activity is needed. Increased efforts are also needed to make comprehensive ED data available to public health programs including occupational injury surveillance.

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