Work-related Amputations in Michigan, 2006

June 2009

Michigan Department of Community Health

MDCH

Jennifer M. Granholm, Governor

Janet Olszewski, Director

MICHIGAN STATE UNIVERSITY

Work-related Amputations in Michigan, 2006

A Joint Report

of the

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June 2009

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This report would not have been possible without the participation of
staff at Michigan hospitals who provided medical records.

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This publication was supported by grant number 1 U60 OH008466-01 from the U.S. Centers for Disease Control and Prevention – National Institute for Occupational Safety and Health (CDC-NIOSH). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of CDC-NIOSH.

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EXECUTIVE SUMMARY

The Division of Occupational and Environmental Medicine at Michigan State University has developed a system for collecting data on work-related amputations in Michigan. This report characterizes these injuries for 2006. The salient findings are as follows:

- The system identified a total of 740 Michigan resident work-related amputations. This corresponds to a rate of 15.7 per 100,000 workers. In comparison, the official U.S. Department of Labor estimate (590) was 20% lower.
- Hospital medical records identified 626 cases. Workers' compensation lost work time claims data identified 114 additional cases which would not have been found using medical records alone.
- The amputation rate for males was nearly six times that for females. Among males, rates were highest for those aged 20-29.
- More than half of the incidents occurred among those working in the manufacturing industry. The specific manufacturing groups with the highest rates were Wood Product Manufacturing, Fabricated Metal Product Manufacturing, and Primary Metal Manufacturing.
- Power saws were the leading cause of amputations.
- Ninety-six percent of amputations involved fingers. One in nine of these finger injuries involved the loss of multiple fingers.
- Among upper extremity amputations, workers sustained more injuries to their left side than their right side regardless of whether they were right-handed, left-handed, or ambidextrous.
- Workers' compensation was the expected source of payment of hospitalization or emergency department care for 76% of the cases for which payment source was identified. Payer source could not be determined for 15% of medical records reviewed.
- One-hundred-thirty-two (132) worksites were referred to the Michigan Occupational Safety and Health Administration (MIOSHA). MIOSHA subsequently inspected 41 of these worksites and assessed an average of 12 violations and $4,000 in fines per inspection.

All Michigan acute care hospitals participated in this surveillance system and were the primary source of data for most (85%) of the identified cases for 2006. Data provided by the Michigan Workers' Compensation Agency identified an additional 15% of cases that would have been missed by hospital-based surveillance alone. The workers' compensation data were limited to individuals who requested wage replacement – they did not capture claims solely for medical care cost reimbursement. Therefore, the surveillance system missed those cases in which injured workers were treated in non-hospital settings or were treated at an out-of-state hospital and did not request wage replacement.

The Michigan work-related amputation surveillance system produces valuable information. It identifies hazardous worksites that otherwise might go undetected and facilitates remediation at these worksites. It provides the best estimate of the true number of amputations that occur in Michigan. It also provides information that can be used to characterize workers and industries with high amputation rates.

This report will be updated annually and made available on the websites of the Michigan Department of Community Health, Division of Environmental Health, and the Michigan State University Division of Occupational and Environmental Medicine.

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INTRODUCTION

An amputation is one of the most debilitating injuries that can occur in the workplace. Unlike many other types of injuries, amputations often cannot be fully mended through medical treatment. Thus, workers sustaining amputations are forced to make significant physical and psychological adjustments both in the workplace and their personal lives.

The Bureau of Labor Statistics estimates that 7,990 amputations resulting in days away from work occurred nationally in the private sector in 2006. The median number of lost workdays was 22 for amputation cases compared to seven days for all work-related injuries.[1] Reducing the incidence of work-related amputations is a federal priority. Between 2001 and 2004, the National Institute for Occupational Safety and Health (NIOSH) collaborated with the Council of State and Territorial Epidemiologists (CSTE) and staff from NIOSH-funded states to develop a set of nineteen occupational health indicators.[2] Two of the indicators were measures of work-related amputations.

The Michigan Occupational Safety and Health Administration (MIOSHA) was established in 1974. MIOSHA is part of the Michigan Department of Energy, Labor and Economic Growth (MDELEG). Its mission is to assure the safety and health of Michigan workers through education and training, consultation, and enforcement. MIOSHA developed a strategic plan for 2004-2008 that included an objective to reduce amputations by 20%[3]. One general strategy listed is to develop cooperative efforts with the occupational safety and health community to identify and address workplace hazards.

In May 2004, staff in the Occupational and Environment Medicine (OEM) Division within Michigan State University's College of Human Medicine began reviewing medical records for patients treated for amputations and referring cases meeting designated criteria to MIOSHA. MIOSHA referrals were tracked through 2005. Beginning with 2006 data, a surveillance system to track all work-related amputations treated at Michigan hospitals was established. In addition, data were obtained from the Michigan Workers' Compensation Agency to supplement the hospital-based data and

provide a more complete count of work-related amputations. This report summarizes work-related amputations identified by this surveillance system for the first full year of data, 2006.

DATA SOURCES and METHODS

Data Sources

Medical records were used to identify work-related amputation cases treated at hospitals. Under the State Public Health Code, Michigan hospitals are required to report these conditions.[4] MSU administers this law for MDELEG and medical records are sent directly to MSU's OEM Division.

The MDELEG Workers' Compensation Agency provided access to a database of claims for wage replacement due to lost work time. To be eligible for wage replacement, an individual must have been out of work seven consecutive days (i.e. five weekdays and two weekend days).

MIOSHA inspection reports were the source of information on the number of violations cited and the total penalties assessed for worksites referred to MIOSHA by the surveillance system for inspection.

The Current Population Survey (CPS), conducted by the U.S. Census Bureau for the Bureau of Labor Statistics, was the source of the estimated number of employed Michigan residents by defined age groups, gender, and industry groups for 2006. The BLS Local Area Unemployment Statistics (LAUS) system, which utilizes CPS data in combination with data from the BLS Current Employment Statistics program and State unemployment insurance systems, was the source of the number of Michigan residents employed by county of residence. The CPS and LAUS employment data were used to calculate worker-based amputation rates.

Methods

A case identified using hospital medical records was defined as an individual aged 16 years or older receiving medical treatment at a Michigan hospital in 2006 for whom: a) an amputation diagnosis was assigned (ICD-9-CM[5] codes 885.0-.1, 886.0-.1, 887.0-.7, 895.0-.1, 896.0-.3, and 897.0-.7); and b) the incident was documented as having occurred at work. The level of hospital care included outpatient surgery, emergency department visit, and hospital admission. A workers' compensation case was defined as an individual aged 16 years or older who sustained an injury in 2006 that was coded as an amputation and submitted a claim for lost work time wage replacement. Cases that listed body parts that were inconsistent with upper or lower extremity amputation (e.g., "eye", "back") were excluded.

Worksites of hospital-treated cases* that met the following additional criteria were referred to MIOSHA: a) the worksite was located in Michigan; and either b) the company's two-digit Standard Industry Classification (SIC)[6] code was among the following: 20, 24, 25, 30, 33, 34, 35, 37† (MIOSHA had identified these as industry categories with high injury rates) or c) the amputation was caused by a mechanical power press.Δ An MSU referral to MIOSHA consisted of copies of medical records that documented the injury, its cause, and the employer (worker's names were

* Cases that were identified solely through workers' compensation records were not referred to MIOSHA. Data provided by the Michigan Workers' Compensation Agency can be used only for research and not for enforcement purposes.

†

SIC Code	Industry
20	Manufacturing – Food and Kindred Products
24	Manufacturing – Lumber and Wood Products, Except Furniture**
25	Manufacturing – Furniture and Fixtures
30	Manufacturing – Rubber and Miscellaneous Plastics Products**
33	Manufacturing – Primary Metal Industries
34	Manufacturing – Fabricated Metal Products, Except Machinery and Transportation Equipment
35	Manufacturing – Industrial and Commercial Machinery and Computer Equipment
37	Manufacturing – Transportation Equipment

** Added in July 2007.

Δ Employers are required to report injuries caused by mechanical power presses directly to MIOSHA within 30 days of the incident. MIOSHA uses referrals for amputations caused by power presses to identify companies that fail to comply with this reporting regulation. Worker's names are used in this process.

suppressed except for cases potentially involving power presses). MIOSHA staff reviewed referred cases to determine if a worksite inspection was warranted. Some medical records lacked information as to whether an amputation occurred at work. In addition, for some work-related cases, the employer was not identified, information necessary to determine if a MIOSHA referral was warranted. In either of these instances, MSU staff attempted to interview the patient by phone to ascertain the salient information.

Referrals were made to MIOSHA between February 2007, when hospitals started to provide medical records for 2006 to MSU, and February 2008.

For all work-related amputation incidents identified from hospital medical records, data collected included: hospital name, date of admission, patient demographics, city and county of residence, primary source of payment, company name, address, SIC code, NAICS (North American Industry Classification System[7]) code, injury date and time, nature of injury (i.e., body part and amount amputated), dominant hand, and cause of injury. For cases referred to MIOSHA, additional information was obtained, including: date of referral, whether an inspection was performed, inspection date, number of violations, power press violations, total fines assessed, and whether the company had been on MIOSHA's "priority list[*]."

Once case ascertainment from medical record review and patient interviews was completed, an attempt was made to manually link records in the work-related amputation database to records in the workers' compensation claims database. There were several steps in the record-linkage process: 1) if last name matched, the match was verified by comparing dates of birth, social security numbers and dates of injury;

[*] Each year, MIOSHA develops a priority list of establishments to inspect. These companies are selected because, as identified using workers' compensation records, they have a higher number of injuries or illnesses resulting in seven or more lost workdays than other companies performing similar work. In addition, MIOSHA inspects a random sample of employers each year. To evaluate if safeguards are maintained, MIOSHA also performs some re-inspections at establishments previously inspected who were found to have five or more serious violations.

2) for the remaining unmatched records, linkage was attempted using date of birth and verified by comparing the other three identifiers; 3) for any remaining unmatched records, the process was repeated by first attempting linkage with social security number. Initially, the matching process was limited to workers' compensation claims in which the injury type was "amputation." Any cases not matching were compared to the remainder of the workers' compensation claims database. Record linkage was also attempted for 20 cases for which work-relatedness could not be determined through medical record review or patient interview.

Work-related amputation rates were calculated by gender, age group, county of residence and type of industry by dividing the number of cases by the number employed and multiplying the result by 100,000. Rates were not calculated for groups with fewer than six cases because these were considered statistically unreliable. Asterisks identify these cases in the tables.

SYMBOLS USED IN TABLES

No cases occurred within category	–
Rate is considered statistically unreliable	*

Database management was conducted using Microsoft Access. Data analysis was performed using SAS software, version 9.1 of the SAS System for Windows (copyright 2002-2003 by SAS Institute Inc.).

RESULTS

One-hundred-twelve (112) of Michigan's 127 acute care, non-federal hospitals submitted medical records to MSU. Each of the 15 hospitals that submitted no records verbally reported that they had no work-related amputation cases in 2006. The total number of records received and reviewed was 1,888. Project staff attempted to interview 136 individuals: 92 to determine if the injury was work-related and 44 to identify the employer. Eighty-seven interviews were completed (64% success rate).

In 2006, 634 individuals were treated at a Michigan acute care hospital following a work-related amputation. These workers made a total of 734 hospital visits for care (85 of the 634 workers made multiple hospital visits). Nearly all workers (98.7%) were Michigan residents (N=626) (Table 1). The work-related amputation rate for these hospital-treated amputations among Michigan residents was 13.3 per 100,000 workers.

TABLE 1
Workers treated for an amputation
at a Michigan acute care hospital, 2006

Characteristic of Worker and Healthcare Utilization	Number of Workers	%
Received treatment at a Michigan acute care hospital	634	100.0
Michigan resident	*626*	*98.7*
One hospital visit	*542*	*85.5*
Multiple hospital visits (followup care or transfer to another hospital)	*84*	*13.2*
Out-of-state resident	*8*	*1.3*
One hospital visit	*7*	*1.1*
Multiple hospital visits (followup care or transfer to another hospital)	1	*0.2*

Data Source: Michigan hospital medical records

Two-hundred-ninety-two (292) Michigan residents submitted workers' compensation claims for lost work time due to work-related amputation injuries in 2006. Of these 292 cases, 178 (61%) were matched with medical records. There

were 131 hospital-record-based cases that matched workers' compensation claims records, but the type of injury listed in workers' compensation was something other than an amputation (e.g., crush, fracture, laceration). Finally, there were twenty individuals who sustained an amputation for whom work-relatedness could not be determined from the medical record or from phone interview. None of these twenty were found in the workers' compensation database. Table 2 illustrates the number of cases ascertained by the two data sources and the results of the matching process.

TABLE 2
Results of matching Michigan work-related amputation cases ascertained from hospital medical records and workers' compensation lost work time claims, 2006

Michigan Resident in Workers' Compensation Database?	Michigan Resident Work-related Amputation Case per Hospital Medical Records or via Patient Interview?		
	Yes	No	Unknown
Yes, with amputation injury	178	114	0
Yes, with a non-amputation injury	131	*	0
No	317	*	20

* Cases in these cells were not ascertained because they were not relevant to identifying work-related amputations.

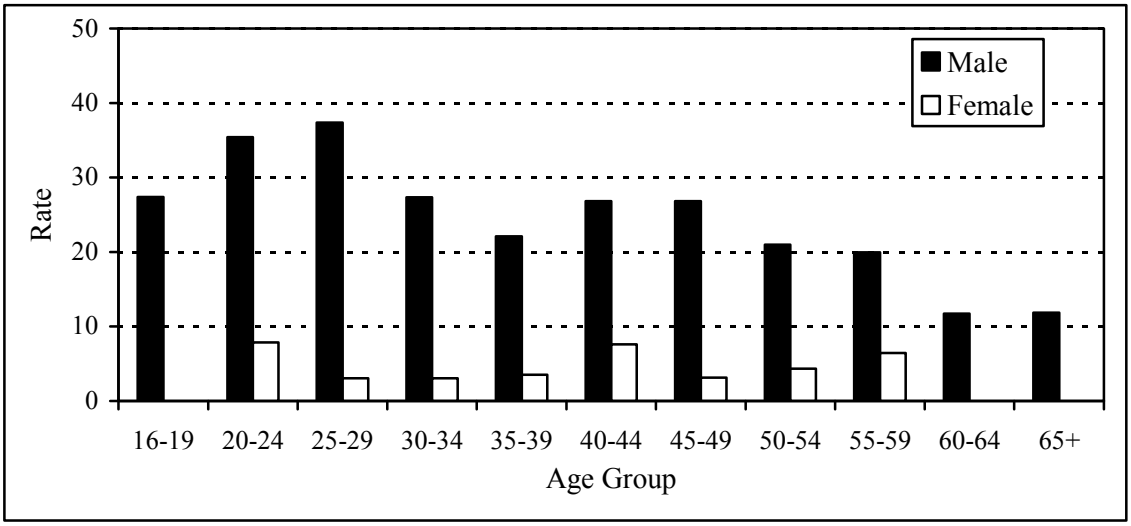
Adding the 114 cases found solely from workers' compensation records to the 626 hospital-based cases yields a total of 740 workers. This corresponds to a rate of 15.7 amputations per 100,000 workers. The following analyses examine these 740 cases.

Characteristics of Injured Workers

Age and Gender

Males comprised 86% of workers who sustained an amputation. Figure 1 displays amputation rates by age group and gender. For three age groups, the number of females injured was insufficient to allow the calculation of statistically valid amputation rates. Among males, rates were highest for the youngest workers, especially those aged 20-29.

FIGURE 1
Work-related amputation rates
by age group and gender
Michigan residents, 2006



Rates are the number of workers sustaining an amputation per 100,000 workers.
Statistically valid rates could not be calculated for females ages 16-19, 60-64 and 65+ due to insufficient numbers of cases.
Data Sources: Number of amputations – Michigan hospital medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency; Number of workers employed by age group used to calculate rates - Bureau of Labor Statistics' Current Population Survey

Race and Hispanic Ethnicity

Information on patient race and Hispanic ethnicity was missing in 39% and 94% of medical records, respectively, and is not collected in workers' compensation claims (see Table A-2 in Appendix A). Due to these levels of missing information, rates for racial/ethnic groups were not calculated.

Body Part and Severity

As shown in Table 3 nearly all amputations were to fingers (96.2%). Six-hundred-seven finger amputation cases were identified through hospital medical records. These records provided more detail on finger injuries than workers' compensation claims data, thus the following analyses are limited to these cases. Of 607 finger amputation incidents, 71 (11.7%) involved multiple fingers. The distal phalanges of the middle and index fingers (sections G and J in Figure 2) were the most frequently amputated areas. The distal phalanges comprised 83% of all finger sections lost (excluding cases in which this information was unknown). Table A-3 and Table A-4 in Appendix A provide these data for the left and right hand separately for single-finger and multiple-finger amputation incidents, respectively.

TABLE 3
Work-related amputations
by injured body part
Michigan residents, 2006

Part of Body Amputated	Number	%
Upper Extremity	723*	97.7
Finger	*712*	96.2
Hand	*7*	0.9
Arm	*3*	0.4
Lower Extremity	16	2.2
Toe	*12*	1.6
Foot	*1*	0.1
Leg	*3*	0.4
Unspecified Body Part	1	0.1
Total	740	100.0

* For one case, the upper extremity body part was unspecified.
Data Sources: Michigan hospital medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency

Among upper extremity amputations, workers sustained more injuries to their left side than their right side regardless of whether they were right-handed, left-handed, or ambidextrous (Table 4). For 38% of upper extremity amputation cases, hand dominance was not specified in medical records.

FIGURE 2
Work-related finger amputations
by digit and portion of finger lost
Michigan residents, 2006

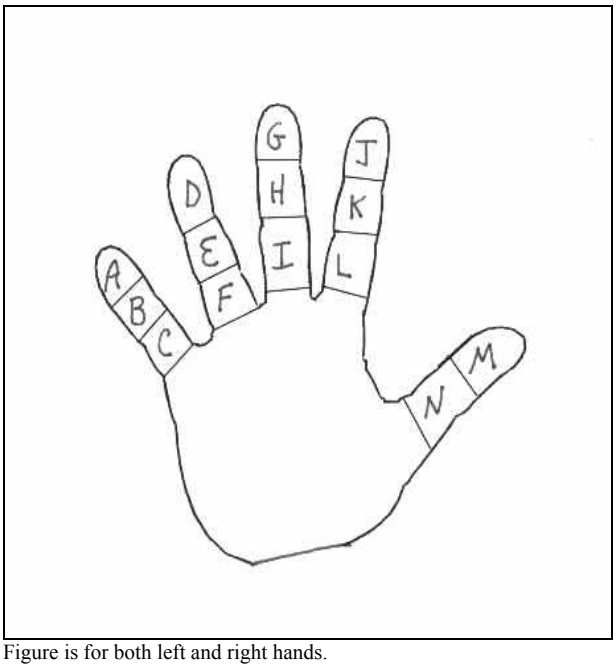


Figure is for both left and right hands.

Finger	Section	Number	%
Little	A	73	10.6
	B	9	1.3
	C	9	1.3
Ring	D	106	15.5
	E	17	2.5
	F	7	1.0
Middle	G	153	22.3
	H	18	2.6
	I	5	0.7
Index	J	144	21.0
	K	28	4.1
	L	8	1.2
Thumb	M	96	14.0
	N	13	1.9
Total		686	100.0

In 25 instances, the section of finger lost was unknown.
Data Source: Michigan hospital medical records

TABLE 4
Work-related upper extremity amputations
by side injured and dominant hand
Michigan residents, 2006

Side Injured	Dominant Hand				Total
	Right	Left	Both	Unknown	
Right	147	15	0	112	274
Left	193	18	5	119	335
Both	2	0	0	2	4
Unknown	0	0	0	1	1
Total	342	33	5	234	614

Data Source: Michigan hospital medical records

County of Residence

Table 5 illustrates the number of workers sustaining an amputation and the corresponding rate by a worker's county of residence. Note that the table does not necessarily reflect the counties with the highest risk worksites because people often work in a county other than the one in which they live. Osceola County had the highest rate although there were only nine cases. All three counties of the Branch-Hillsdale-St. Joseph health region were among the nine counties with the highest rates. Montcalm, Ionia, and Kent Counties comprised another set of contiguous counties with elevated rates. Among the most populous counties in the state, Muskegon County had the highest worker amputation rate.

Case Study One

An eighteen-year-old right-handed male was working at a company that manufactures leather mechanical packings. The medical record indicated that an unspecified type of press came down on his right index finger, amputating it just proximal to the distal interphalangeal joint. The case was referred to MIOSHA and two months later they inspected the worksite. The company, which had not been on MIOSHA's priority list of establishments to inspect, was cited for eight violations, including one for the lack of a power press guard and one for failure to report this power press injury. The company was fined $400.

TABLE 5
Number and rate of work-related amputations
by county of residence, Michigan residents, 2006

County	Number	Rate	County	Number	Rate
Alcona	2	*	Lapeer	11	26.5
Alger	0	-	Leelanau	0	-
Allegan	15	28.1	Lenawee	8	17.1
Alpena	2	*	Livingston	11	12.2
Antrim	3	*	Luce	2	*
Arenac	2	*	Mackinac	0	-
Baraga	0	-	Macomb	61	15.6
Barry	4	*	Manistee	0	-
Bay	9	17.2	Marquette	3	*
Benzie	2	*	Mason	6	43.1
Berrien	13	17.6	Mecosta	2	*
Branch	8	37.9	Menominee	2	*
Calhoun	15	22.6	Midland	1	*
Cass	1	*	Missaukee	3	*
Charlevoix	2	*	Monroe	17	23.0
Cheboygan	4	*	Montcalm	10	40.2
Chippewa	1	*	Montmorency	2	*
Clare	3	*	Muskegon	31	36.6
Clinton	0	-	Newaygo	5	*
Crawford	1	*	Oakland	41	6.9
Delta	4	*	Oceana	2	*
Dickinson	1	*	Ogemaw	3	*
Eaton	5	*	Ontonagon	0	-
Emmet	2	*	Osceola	9	94.2
Genesee	27	13.8	Oscoda	2	*
Gladwin	2	*	Otsego	4	*
Gogebic	1	*	Ottawa	31	23.7
Grand Traverse	7	15.0	Presque Isle	1	*
Gratiot	5	*	Roscommon	2	*
Hillsdale	12	57.8	Saginaw	11	12.0
Houghton	1	*	St. Clair	14	18.1
Huron	4	*	St. Joseph	10	33.7
Ingham	14	9.7	Sanilac	2	*
Ionia	10	34.3	Schoolcraft	0	-
Iosco	1	*	Shiawassee	13	38.2
Iron	0	-	Tuscola	7	26.0
Isabella	4	*	Van Buren	6	15.5
Jackson	7	9.6	Washtenaw	5	*
Kalamazoo	15	11.7	Wayne, including Detroit	111	13.6
Kalkaska	4	*	*Detroit*	*48*	*15.1*
Kent	64	20.8	Wexford	1	*
Keweenaw	1	*	Unknown	12	-
Lake	0	-	Michigan	740	15.7

Rates are the number of workers sustaining an amputation per 100,000 workers.
Data Sources: Number of amputations – Michigan hospital medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency; Number of workers used to calculate rates – Bureau of Labor Statistics' Local Area Unemployment Statistics

Industry

Table 6 illustrates the number and corresponding rate of work-related amputations by industry. For 19% of cases, there was insufficient information in either the medical records provided or workers' compensation claims data to make an industry classification. Thirty-nine workers were described in medical records as self-employed. Industry could be ascertained for six of these self-employed workers; the remaining 33 were included in Unknown Industry. Among two-digit NAICS industry groups, Agriculture/Forestry/Fishing/Hunting had the highest rate. However, there were twelve times as many incidents within Manufacturing. In addition, certain three-digit NAICS groups within Manufacturing had very high rates, such as Wood Product Manufacturing (121.7 per 100,000 workers), Fabricated Metal Product Manufacturing (113.1 per 100,000), and Primary Metal Manufacturing (84.5 per 100,000).

Case Study Two

A 32-year-old male was using his foot to push wood into a chipper when he slipped. His right foot went into the chipper amputating his heal. At the hospital, he subsequently had a below-knee amputation. The case was not referred to MIOSHA because the employer's industry (Lawn and Garden Services – SIC 0782) was not within the range specified in the referral criteria.[*]

[*] In September 2008, MIOSHA revised the composition of industries to be referred. The new criteria include SIC 0782.

TABLE 6
Number and rate of work-related amputations
by worker industry, Michigan residents, 2006

Industry Classification (NAICS code)	Number	Rate
Agriculture, Forestry, Fishing, Hunting (11)	26	40.9
Mining (21)	3	*
Utilities (22)	3	*
Construction (23)	73	25.8
Manufacturing (31 – 33)	310	33.4
Food Manufacturing (311)	*22*	*81.0*
Wood Product Manufacturing (321)	*17*	*121.7*
Paper Manufacturing (322)	*9*	*56.3*
Plastics & Rubber Products Manufacturing (326)	*18*	*43.3*
Primary Metal Manufacturing (331)	*32*	*84.5*
Fabricated Metal Product Manufacturing (332)	*78*	*113.1*
Machinery Manufacturing (333)	*36*	*39.9*
Transportation Equipment Manufacturing (336)	*52*	*13.1*
Furniture & Related Product Manufacturing (337)	*13*	*31.7*
Wholesale Trade (42)	31	20.1
Retail Trade (44 – 45)	37	7.2
Transportation & Warehousing (48 – 49)	12	8.2
Information (51)	3	*
Finance & Insurance (52)	3	*
Real Estate and Rental & Leasing (53)	8	10.1
Professional, Scientific, and Technical Services (54)	3	*
Management of Companies & Enterprises (55)	1	*
Administration & Support Services and Waste Management & Remediation Services (56)	18	11.1
Educational Services (61)	11	2.6
Health Care & Social Assistance (62)	8	1.4
Arts, Entertainment & Recreation (71)	4	*
Accommodation & Food Services (72)	34	11.2
Other Services (81)	10	4.3
Public Administration (92)	3	*
Unknown Industry	139	-
Total	740	15.7

Rates are the number of workers sustaining an amputation per 100,000 workers.
Data Sources: Number of amputations – Michigan hospital medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency; Number of workers by industry used to calculate rates: Bureau of Labor Statistics' Current Population Survey

Causes of Amputations

Causes of work-related amputations are illustrated in Table 7. (This information was unavailable in workers' compensation claims data, so the table is limited to the 626 cases that were identified via medical record review.) Sharp objects were identified in more than one-quarter (28.0%) of the cases. Within this category, power saws (e.g., table saws, miter saws) predominated. Presses caused one in nine (10.9%) amputations. Medical records generally did not specify the type of press.

TABLE 7
Number of work-related amputations, by cause of injury
Michigan residents, 2006

Cause of Injury	Number	%
Sharp Object	175	28.0
Power Saw	*91*	*14.5*
Meat Slicer	*16*	*2.6*
Fan	*2*	*0.3*
Router	*2*	*0.3*
Snowblower	*2*	*0.3*
Jointer	*1*	*0.2*
Lawn Mower	*2*	*0.3*
Staple Gun	*1*	*0.2*
Other Sharp Object	*56*	*8.9*
Press	68	10.9
Mechanical/Punch/Stamping Press	*9*	*1.4*
Hydraulic Press	*2*	*0.3*
Rolling Press	*1*	*0.2*
Drill Press	*1*	*0.2*
Unspecified Type of Press	*55*	*8.8*
Grinder	11	1.8
Auger	2	0.3
Log Splitter	2	0.3
Sander	2	0.3
Machine – Other & Unspecified Type	89	14.2
Chain/Pulley/Gears/Belt	51	8.1
Crushed/Pinched in Door	7	1.1
Pinched Between/In Other Objects	76	12.1
Struck by Falling Object	44	7.0
Struck by Object – Other	27	4.3
Fall	3	0.5
Other Specified Cause	19	3.0
Unspecified Cause	50	8.0
Total	626*	100.0

* Workers' compensation claims data do not contain cause of injury information and thus are excluded from the table.
Data Source: Michigan hospital medical records

An assortment of other machinery, many of which were unspecified in the medical records reviewed, caused one in seven amputations. Another frequent cause of amputations was workers getting pinched or crushed between objects, such as doors. Finally, medical records provided no information on cause in 8.0% of cases.

Source of Payment

As shown in Table 8, of the cases identified through hospital medical records, workers' compensation was the expected payer in 402 or 76% of the 529 cases for which payment source was specified. For 97 of the 626 cases, payment source could not be identified.

TABLE 8
Work-related amputations
by payment source
Michigan residents, 2006

Expected Source of Payment	Number	%
Workers' compensation	402	76.0
Commercial insurance	79	14.9
Other	48	9.1
Total	529*	100.0

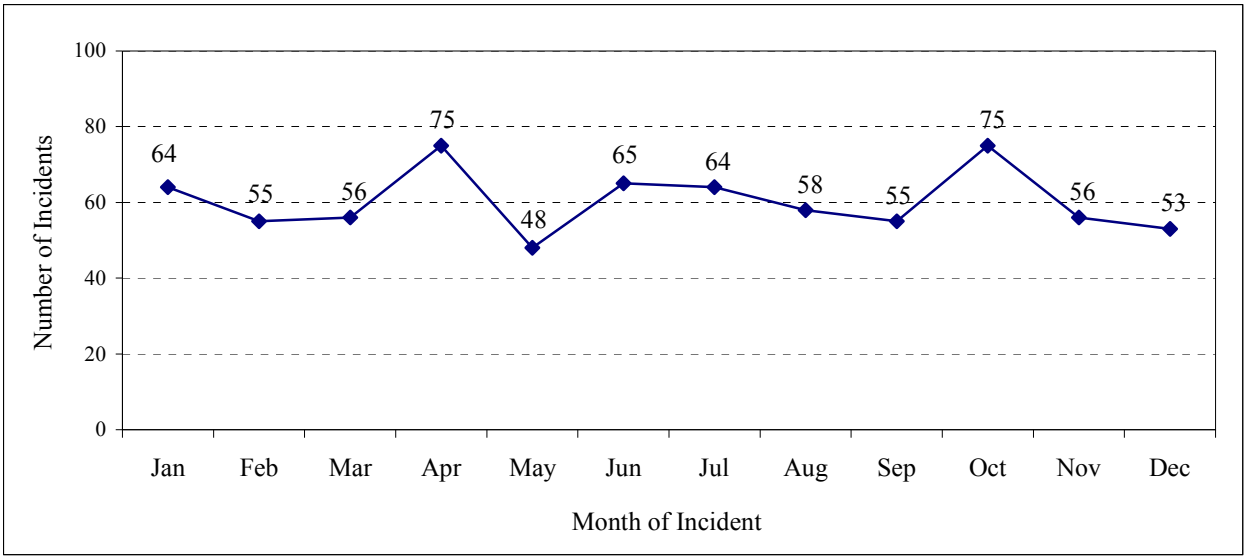
* For 97 amputations source of payment was unknown.
Data Source: Michigan hospital medical records

Temporal Characteristics

Incidents by Month

There was no clear seasonal trend to work-related amputations (Figure 3). The largest number of incidents occurred in April and October.

FIGURE 3
Work-related amputations
by incident month
Michigan residents, 2006

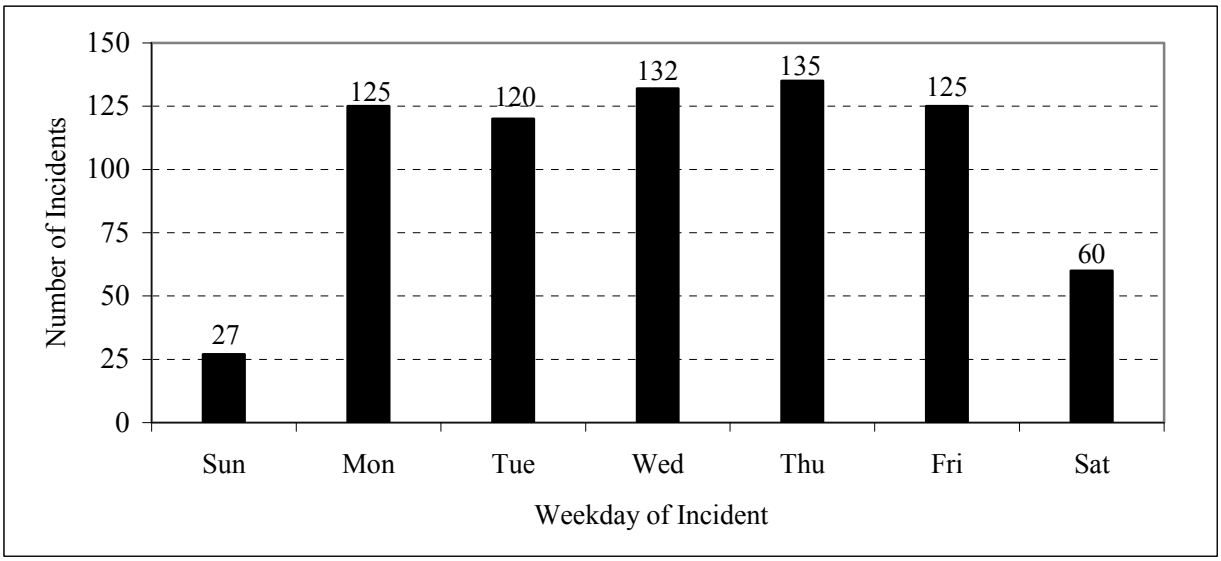


Month of incident was unknown for sixteen cases.
Data Sources: Michigan hospital medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency

Incidents by Weekday

Amputations occurred more often during the normal work week (Monday through Friday) than during the weekend (Figure 4). Incidents seemed to be slightly elevated on Wednesday and Thursday.

FIGURE 4
Work-related amputations
by weekday of incident
Michigan residents, 2006

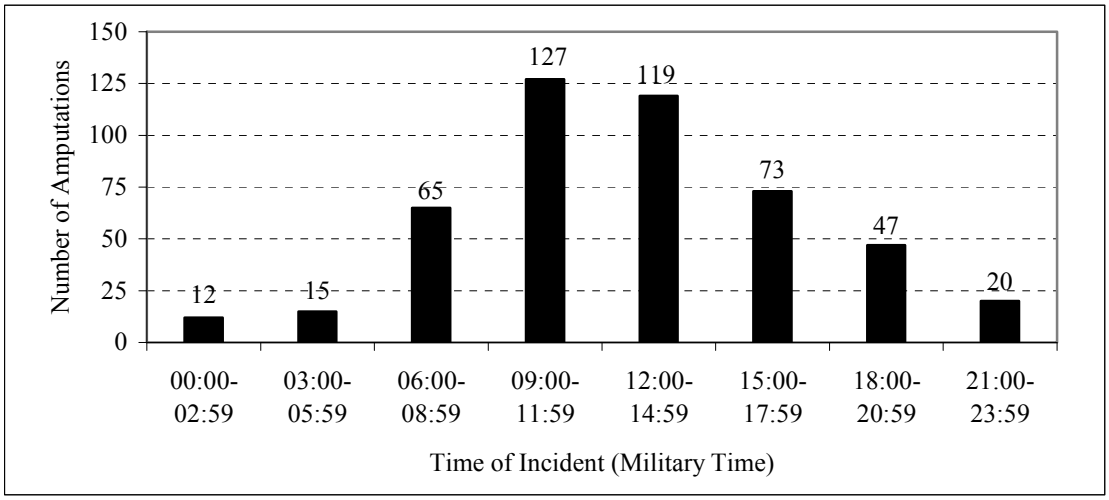


Day of incident was unknown for sixteen cases.
Data Sources: Michigan hospital medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency

Incidents by Time of Day

Figure 5 illustrates the number of amputations by incident time. Most occurred between 9:00 AM and 2:59 PM. (Cases identified solely via workers' compensation claims are not shown because these records do not include incident time.)

FIGURE 5
Work-related amputations
by time of incident
Michigan residents, 2006



Time of incident was unknown for 148 cases.
Data Source: Michigan hospital medical records

Referrals to MIOSHA

One hundred forty two (142) of the 626 work-related amputations identified from hospital medical records met the MIOSHA referral criteria.* Most of these cases (N=123) involved one amputation per worksite. At eight worksites, two separate amputation incidents occurred. At one worksite, three incidents occurred. Thus, MSU referred 132 worksites to MIOSHA.

* Cases identified solely through workers' compensation records were not referred to MIOSHA. See *Methods*.

Table 9 illustrates the outcome of these referrals. MIOSHA inspected 45 worksites subsequent to MSU referrals, 27 of which had not been on their priority list. These 27 worksites most likely would not have been inspected if not for the MSU referrals. Referrals were likely responsible for many of the inspections at the 18 worksites that had been on the MIOSHA priority list. Fourteen of these 18 inspections occurred within twelve months of an MSU referral, twelve of which occurred within three months of the referral. Because of limited resources, MIOSHA does not inspect all the companies on their priority list.

TABLE 9
Outcome of work-related amputation referrals to MIOSHA
Michigan residents, 2006

Outcome of Referral	Number of Worksites	%
Worksite inspected subsequent to referral	45	34.1
Company not on MIOSHA priority list	*27*	*20.5*
Company on MIOSHA priority list	*18*	*13.6*
Worksite not inspected subsequent to referral	87	65.9
Worksite inspected prior to referral	*20*	*15.2*
Worksite not inspected	*67*	*50.8*
Total	132	100.0

Table 9 also illustrates that in 87 cases, MIOSHA did not perform inspections following MSU referrals. In 20 instances, they had already inspected the worksite prior to receiving the MSU referral. For 67 worksites that were referred, MIOSHA conducted no inspections. For 15 of these, the reasons listed by MIOSHA for not inspecting included: a) the company had closed; b) the worksite was too large;[*] and c) the company had

[*] MIOSHA conducts a "focused inspection" – one that is limited to a specific alleged hazard – if they learn of an injury within six months of its occurrence. Otherwise, MIOSHA conducts a "planned inspection" which covers the entire worksite. At very large worksites, planned inspections require extensive resources.

agreed to work with MIOSHA's Consultation, Evaluation and Training (CET) Division.** For the remaining 52 referrals, MIOSHA did not provide individual explanations for their decision to not inspect. MIOSHA does not assign a referral for inspection when: there is no MIOSHA rule to cover the condition; the amputation is outside the scope of MIOSHA coverage; or the time for assigning a referral for inspection has been exceeded. MIOSHA is more apt to assign for inspection when the cause of the amputation is likely to be found by the safety officer. For example, a worksite in which a machine with potentially insufficient safety features caused an amputation is more likely to be inspected than a worksite in which a worker's finger was pinched between two heavy steel beams.

The following analyses examine the outcome of 41 inspections that were performed subsequent to an MSU referral and either: a) occurred within twelve months of the referral; or b) involved worksites not on MIOSHA's priority list. These represent inspections that were likely due to MSU referrals.

Table 10 summarizes the number of violations identified in these inspections. The maximum number of violations was 38 and the median was 12. Table 11 illustrates the distribution of assessed penalties. The highest penalty was $134,310 and the median was $4,000. MIOSHA cited eight companies for mechanical power press violations.

TABLE 10
Violations identified in worksite inspections conducted within one year following MSU referral or involving companies not on MIOSHA's priority list
Michigan residents, 2006

Number of Violations	Number of Inspections	%
0	0	0.0
1-9	15	36.6
10-19	13	31.7
20+	13	31.7
Total	41	100.0

Data Source: MIOSHA inspection reports

** In working with the MIOSHA CET Division, employers voluntarily request an inspection and are protected from penalties. They must agree to correct all serious violations found during the voluntary inspection.

TABLE 11
Penalties assessed in worksite inspections conducted within one year following MSU referral or involving companies not on MIOSHA's priority list
Michigan residents, 2006

Penalty Assessed	Number of Inspections	%
$0	1	2.4
$1 - $999	11	26.8
$1,000 - $4,999	12	29.3
$5,000 - $9,999	11	26.8
$10,000 and above	6	14.6
Total	41	100.0

Data Source: MIOSHA inspection reports

Case Study Three

A 53-year-old male caught his right hand in a dust collector fan and sustained amputations to his index, middle and ring fingers at the proximal interphalangeal joints. The name of the employer was not specified in the medical record; however, it was ascertained through an interview with the worker. The employer was referred to MIOSHA. Within a month of the referral, MIOSHA inspected the worksite which had not been on their priority list. Two violations were cited, including one for not enforcing a lockout procedure for the employee working on the dust collector. The company was fined $1,050.

Discussion

The Michigan work-related amputation surveillance system is valuable in several ways. First, the system provides information to allow MIOSHA to inspect worksites and find hazards that might otherwise remain undetected. In 2006, there were as many as forty-one such cases. This identification and referral system is clearly consistent with one of the "Strategies to Achieve Goals" listed in MIOSHA's 2004-2008 strategic plan[3]:

> *Develop partnerships and other cooperative efforts with the occupational safety and health community to identify and address significant workplace hazards.*

In addition, the system provides information on the number of amputation incidents by worker demographics and type of industry. The corresponding rates identify high risk worker groups and industries. Lastly, the system can be used to highlight temporal characteristics and the leading causes of amputations.

Evaluation of Surveillance System Attributes

There are seven measures by which a surveillance system can evaluated to determine if it is effective and efficient.[8] These attributes are used to characterize the Michigan work-related amputation surveillance system.

Sensitivity – the proportion of all cases that are detected by the surveillance system

The surveillance system is designed to detect work-related amputations treated in Michigan hospitals or for which the worker submits a claim for wage reimbursement. The following factors prevented the system from being 100% sensitive in 2006:

1) *Incomplete submission of cases by hospitals* – Fifteen hospitals reported treating no work-related amputations cases in 2006 and consequently submitted no medical records to MSU. An analysis of a database consisting of Michigan outpatient and inpatient visits[*] in 2006 identified eight patients treated at five of these hospitals that had an amputation diagnosis and

[*] This database is comprised of outpatient procedures and hospitalizations (inpatient stays). Thus, it misses most patients who are treated and released from emergency departments.

workers' compensation listed as the primary source of payment. (Based on matching zip code of residence, date of birth and date of injury/hospital admission, three of these eight individuals were among the 114 cases identified solely through workers' compensation claims data.)

Several hospitals submitted medical records only for amputations that they identified as work-related. Because work-relatedness is not always readily apparent (e.g., MSU staff were able to identify some cases only through an interview), it is likely that these hospitals did not submit records for all cases. Statewide emergency department data would provide the best estimate of under-reporting due to incomplete record submission by hospitals. However, this data source currently does not exist in Michigan. The surveillance system's sensitivity would be improved if all hospitals submitted medical records for all amputations and did not attempt to filter out non-work-related cases.

2) *Incomplete identification of cases by MSU* – For 20 cases, work-relatedness could not be determined because attempts to interview these patients were unsuccessful. Some of these amputations may have been work-related although none were found among workers' compensation claims data.

3) *Incomplete identification of amputation injuries in workers' compensation claims records* – For a substantial number of work-related amputations identified via medical record review (N=131) the injury type listed in the workers' compensation claims records was something other than an amputation (see Table 2). There may have been other instances in which injuries were not coded as amputations in workers' compensation records but should have been.

There are other work-related amputations that occur in Michigan that the system is not designed to capture, but are worth noting:

1) *Treatment at out-of-state hospitals* – Some amputations that occurred at Michigan worksites were likely treated at out-of-state hospitals. These hospitals were not required to report the incidents to MIOSHA/MSU. The Michigan Inpatient Database (MIDB) can be used to approximate the number of incidents that were not identified for this reason. While the MIDB does not specify state of injury occurrence, it does contain information on Michigan residents hospitalized out of state. In 2006, 3.9% of Michigan resident inpatients with an amputation diagnosis were hospitalized in either Indiana, Ohio, or Wisconsin. Some of these injuries likely occurred in Michigan. Based on this information, it is estimated that in 2006, the surveillance system probably missed at most 3% (about 20 cases) of work-related amputations occurring in Michigan due to treatment at out-of-state hospitals. Note that some of these cases could have been captured via the surveillance system's workers' compensation claims component.

2) *Non-hospital medical treatment with no workers' compensation claim submission* – The hospital record component of the surveillance system misses workers who either are not treated medically (an unlikely occurrence) or are treated at non-hospital settings (e.g., company clinics, urgent care centers). The workers' compensation component misses cases in which injured workers do not submit a claim for wage reimbursement for lost work time. The number of such cases is unknown but presumably limited to the less severe cases.

Some context for the ability of the system to ascertain work-related amputations is provided by an estimate from an independent source. The Bureau of Labor Statistics' Survey of Occupational Injuries and Illnesses (BLS SOII), which reports the official

statistics on work-related injuries and illnesses, estimates that in 2006 there were 590 amputations at Michigan worksites that resulted in days away from work.[9] A study of Michigan work-related amputations estimated that the BLS SOII undercounted incidents in 1997 by 36%.[10] In 2006, the BLS survey underestimated work-related amputation incidence by at least 21%.[*] We are hopeful that a study can be initiated to examine the degree to which Michigan work-related amputation cases overlap in the hospital data system, workers' compensation records and the BLS SOII. Such a matching would allow an even more accurate count of work-related amputations.

Predictive Value Positive (PVP) – the proportion of persons identified as cases that actually have the condition being monitored

The PVP of cases identified from hospital medical records is likely high (i.e., greater than 95%). For these to be classified as cases: 1) the incident must have occurred at work; and 2) the injury must have been coded as an amputation. Incidents were coded as work-related if: a) medical records documented that they occurred at work; b) the expected payer was workers' compensation; or c) the patient reported the incident as work-related during the phone interview. In a few instances, injuries were described as serious avulsions in medical records, but were subsequently coded (using ICD-9-CM) as amputations. The PVP of cases identified solely through workers' compensation records may be slightly lower because information on injury type is provided by employers rather than medical professionals.

Representativeness – the degree to which identified cases accurately describe all cases

The surveillance system appears to represent work-related amputations well geographically. Most hospitals submitted medical records. The 12% of hospitals that reported having no cases were distributed throughout all regions of the state. Self-employed workers were more likely than other workers to be under identified because

[*] The BLS estimate of 590 was 158, or 21%, less than the 748 comparably-defined workers identified by our system. (The BLS estimate includes out-of-state residents, but excludes incidents occurring at out-of-state companies. Our figure of 740 Michigan resident cases was thus adjusted to include 10 out-of-state residents (8 from medical records, 2 from workers' compensation claims), and exclude 2 workers injured at out-of-state companies.)

work-relatedness often could not be determined from medical records and this group is not covered by workers' compensation.

Timeliness – the delay between any two or more steps in the system

The timeliness of the system is its weakest attribute. Medical records for patients treated in 2006 were initially received in February 2007. The last reporting hospital submitted records in March 2009. In April 2009, patient interviewing was completed (i.e., either patients were successfully contacted and interviewed or it was determined that the patient could not be interviewed), all medical records were reviewed and data on work-related amputations entered into a database. At this point, data from workers' compensation claims were obtained and record matching was performed. Timeliness is also a concern with regard to making referrals to MIOSHA. Worksite inspections could be better targeted if the time between injury incidence and MIOSHA referral was reduced. However, the timeliness of referrals is limited due to the timeframe in which medical records are submitted by hospitals.

Flexibility – the ability of the system to adapt to changing needs

The system is highly flexible. Data items ascertained from medical records or through follow-up interviews have been added or deleted as their usefulness has become apparent. In addition, the criteria for cases to be referred to MIOSHA have evolved. For example, in July 2007, MIOSHA expanded the scope of industries eligible for referral (two-digit SIC codes 24 and 30 were added).

Simplicity – the ease of operating the system and the complexity of its design

The case definition is easy to apply and usually cases are identified quickly. For 136 of 1,888 (7.2%) of the medical records reviewed case identification was more complex because additional information was sought through an interview. However, with the recent addition of workers' compensation data to the system, this number should decrease in future years as work-relatedness will be resolved through record matching. Almost none of the data items ascertained from medical records or MIOSHA inspection reports

are complex. There are a small number of individuals involved in maintaining the system. At MSU, one person is responsible for pursuing hospital medical record submission, one person reviews medical records, makes referrals to MIOSHA, performs data abstraction, data entry, and analysis. A third person is responsible for linking medical records and workers' compensation claims records. All individuals working on the system spend only a portion of their time on this project. At MIOSHA, there is one point of contact who receives referrals and returns inspection reports and one individual who determines whether a worksite inspection is warranted.

Acceptability – the willingness of individuals and organizations to participate

All hospitals responded to MSU's request for medical records on work-related amputations either by submitting records or reporting having no cases. Project staff had a 64% success rate in obtaining information from patients via phone interview. Unsuccessful attempts were due mainly to an inability to contact patients because of out-of-date mailing addresses or phone numbers. A few were due to their unwillingness to participate. MIOSHA has stated that they value referrals although they would prefer better timeliness. The Workers' Compensation Agency readily provides access to their data.

Limitations

The surveillance system had several limitations due to the quality and type of information provided in medical records and workers' compensation claims data.

1. Medical records often were non-specific in documenting the causes of amputations. This was especially detrimental when injuries were caused by a "press": either a power press was incorrectly listed as the cause, or a power press was in fact the cause, but not explicitly noted.
2. Medical records sometimes provided insufficient information to identify an industry and assign a SIC code without patient interviews. This is likely to have resulted in some cases not being referred to MIOSHA that should have been.

3. Hospitals varied substantially in the degree to which they provided information on patient race and Hispanic ethnicity. Overall, there was too much missing information for these important demographics to be analyzed.
4. Workers' compensation claims data did not include information on injury cause and lacked detailed injury information (e.g., single vs. multiple digit loss, which hand/finger was injured). Thus, results on these characteristics could not be fully described.
5. The success of record linkage depended upon the accuracy of the linking variables. If any case listed by workers' compensation as an amputation should have been linked to a medical record but was not, it was counted more than once.

Conclusions

This surveillance system provides a more accurate estimate of the true number of work-related amputations than any single source of Michigan work-related injury data (e.g., hospital medical records, workers' compensation claims, or the Bureau of Labor Statistics' Survey of Occupational Injuries and Illnesses). In addition, the hospital-based data can be used for public health interventions to identify and mitigate the hazards that cause amputations. Given the success of the surveillance system, we plan to continue tracking amputations and facilitating workplace investigations. The ultimate objective is to significantly reduce the incidence of this serious injury.

APPENDIX A

Data Tables

TABLE A-1
Number and rate of work-related amputations
by age and sex
Michigan Residents, 2006

Age Group	Male		Female		Total	
	Number	Rate	Number	Rate	Number	Rate
16-19	29	27.4	5	4.3	34	15.3
20-24	76	35.4	16	7.9	92	22.0
25-29	79	37.4	7	3.1	86	19.5
30-34	81	27.3	7	3.0	88	16.7
35-39	72	22.1	9	3.5	81	13.9
40-44	87	26.8	20	7.6	107	18.2
45-49	88	26.8	9	3.1	97	15.8
50-54	62	21.0	12	4.3	74	12.9
55-59	40	19.9	12	6.4	52	13.4
60-64	12	11.7	3	3.2	15	7.6
65+	10	11.9	1	1.3	11	6.9
Total	639	25.7	101	4.6	740	15.7

* Statistically stable rate could not be calculated.
Rates are the number of workers sustaining an amputation per 100,000 workers.
Age was unknown for three males.
Data Sources: Number of amputations – Michigan hospital medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency; Number of workers employed by age group used to calculate rates - Bureau of Labor Statistics' Current Population Survey

TABLE A-2
Number of work-related amputations
by race and Hispanic ethnicity
Michigan residents, 2006

Race	Hispanic Ethnicity			Total
	Yes	No	Unknown	
White	0	0	332	332
Black	0	0	45	45
Other	0	0	7	7
Unknown	35	0	321	356
Total	35	0	705	740

Data Sources: Michigan hospital medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency

TABLE A-3
Work-related single-finger amputation incidents (N=536)
by injured hand and amount of finger lost
Michigan residents, 2006

Hand	Finger	Section Lost				Total
		Distal Phalanx	Middle Phalanx	Proximal Phalanx	Unknown	
Right	Thumb	34		3	5	42
	Index	55	9	3	3	70
	Middle	64	3	0	0	67
	Ring	29	2	0	1	32
	Little	32	1	1	0	34
Left	Thumb	56		5	1	62
	Index	72	13	0	1	86
	Middle	53	2	0	5	60
	Ring	43	4	0	0	47
	Little	29	4	2	0	35
Total		467	38	14	16	535*

* For one thumb injury there was no information on injury side or injury severity.
Data Source: Michigan hospital medical records

TABLE A-4
Work-related multiple-finger amputation incidents (N=71)
by injured hand and amount of finger lost
Michigan residents, 2006

Hand	Finger	Section Lost				Total
		Distal Phalanx	Middle Phalanx	Proximal Phalanx	Unknown	
Right	Thumb	4		3	0	7
	Index	6	4	2	1	13
	Middle	10	7	2	1	20
	Ring	10	8	2	1	21
	Little	4	3	1	0	8
Left	Thumb	2		2	1	5
	Index	11	2	3	0	16
	Middle	26	6	3	2	37
	Ring	24	3	5	2	34
	Little	8	1	5	0	14
Total		105	34	28	8	175

Data Source: Michigan hospital medical records

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